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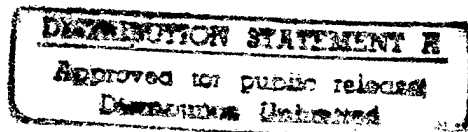
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OFFICE OF  
ENVIRONMENT AND SAFETY

**INVENTORY OF ACID DEPOSITION  
RESEARCH PROJECTS FUNDED BY THE  
PRIVATE SECTOR**

**FINAL REPORT**

**(January-October 1982)**



DTIC QUALITY INSPECTED 2

**Gas Research Institute  
8600 West Bryn Mawr Avenue  
Chicago, Illinois 60631**

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Report 1277-01-82-CR

# **Inventory of Acid Deposition Research Projects Funded by the Private Sector**

By:

John D. Kinsman  
Joe Wisniewski

December 1982

**GENERAL  
RESEARCH**  **CORPORATION**

**RESOURCE MANAGEMENT OPERATIONS**

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Prepared For:

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<b>16. Abstract (Limit: 200 words)</b> One hundred twenty-four privately funded acid rain research projects, each with funding over \$5000, were documented. Individuals from over 13 industry/special interest groups were contacted (including gas, electric, petroleum, paper, coal, automobile, etc.). Information was solicited on research in the following areas: emissions, transport, chemistry, removal/deposition, collection/analysis, environmental effects, mitigation, legal, and economics. For each inventoried project, the following information was obtained: project title, funding organization, project officer, research organization and principal investigator, period of performance, funding, research objectives, project description, and expected output. Each of the inventoried studies was categorized by major research objectives into one of the following four research categories: 1) atmospheric processes; 2) environmental effects; 3) emissions and monitoring; and 4) other projects. A detailed cross-reference subject index is provided as an appendix.							
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### Research Summary

Title: Inventory of Acid Deposition Research Projects Funded by the Private Sector

Contractor: General Research Corporation  
GRI Grant Number: 5081-351-0482  
(cofunded by EPRI, EEI and API)

Principal Investigator: J. Wisniewski, J. Kinsman

Report Period: January - October 1982  
Final Report

Objective: To provide a comprehensive, up-to-date inventory of privately funded research activities on acid deposition currently being performed across the country.

Technical Perspective: Numerous potential sources of acid rain exist, and the geographic extent of the impacts is widespread. Approximately 12% of the total nitrogen dioxide produced by the combustion of fossil fuels comes from natural gas. The relationship between these emissions and the potential for acid deposition has not been established. The increase in research privately funded on the entire acid rain issue suggests that there is a need to identify all such ongoing research activities. A comprehensive survey of the ongoing research in acid rain will prevent duplication of research and ensure coordination of financial and technical resources. Such an inventory shall provide a basis for future direction among research participants.

Results: One hundred twenty-four privately funded acid rain research projects, each with funding over \$5000, were documented. The projects were classified under four topic areas:  
1) atmospheric processes; 2) environmental effects;  
3) emissions and monitoring; and 4) other projects. The largest percentage of research projects is in the area of emissions and monitoring.

Technical Approach: General Research Corporation contacted approximately 230 individuals associated with acid-rain-related research within the private sector. Many of these contacts were supplied by the funding organizations while others were suggested during the course of telephone conversations. Individuals from over 13 industry/special interest groups were contacted (including gas, electric, petroleum, paper, coal, automobile, etc.). Information was solicited on research in the following areas: emissions, transport, chemistry, removal/deposition, collection/analysis, environmental effects, mitigation,

legal, and economics. For each inventoried project, the following information was obtained: project title, funding organization, project officer, research organization and principal investigator, period of performance, funding, research objectives, project description, and expected output. Each of the inventoried studies was categorized by major research objectives into one of the four previously mentioned research categories. A detailed cross-reference subject index is provided as an appendix.

Project

Implications: This inventory of privately funded acid deposition research work will make it possible to conduct a more effective exchange of information and to identify areas where research is lacking. An earlier study identified federally funded acid rain research work. GRI's future efforts in acid rain research will be guided by both of these studies.

GRI Project Manager:

D.O. Johnson

Assistant Director, Environment and Safety Research

#### ACKNOWLEDGMENT

We acknowledge the contributions of the four entities which equally co-funded this effort: the Electric Power Research Institute (EPRI), the American Petroleum Institute (API), the Edison Electric Institute (EEI), and the Gas Research Institute (GRI). We especially appreciate the continual support and guidance provided by Jimmie Nelson of API, who served as technical manager for the project. Many individuals supplied information for this study. It would be cumbersome to name everyone here, but their contributions are greatly appreciated. Finally, we wish to thank Donna Dotson for clerical preparation of this document.

## FOREWARD

The occurrence of acid deposition has become a well-recognized concern to countries in North America, Europe, and Scandinavia. Because of the wide geographical spread and the large number of potential sources of acid deposition, both the government and private sector have an interest in determining the exact nature and consequences of the phenomenon. However, the constant generation of new data in the areas of emissions and monitoring, atmospheric processes, environmental effects, and economics and policy, necessitates the identification of research activities and the dissemination of this information to researchers and policymakers.

Therefore, a well-coordinated survey was undertaken in order to prevent needless duplication of research and to ensure carefully planned utilization of financial and technical resources. To this end, this inventory of private sector-supported acid deposition research should provide a basis for a coordinated plan of research among funding and research organizations.

The report that follows summarizes research supported by the private sector during FY80, FY81, and most of FY82 to determine the nature and magnitude of the acid deposition problem.

Jimmie Nelson  
Environmental Affairs Division  
American Petroleum Institute



# ABSTRACT

This document contains a description of acid deposition-related research projects funded by the private sector during 1980, 1981 and 1982. The projects listed are either being performed internally by the particular entity or contracted out to universities, private firms, etc. This is the first attempt at assembling an inventory of private sector-funded acid deposition research. Some of the summaries are incomplete because all desired information was not available from the performing or sponsoring institutions. In addition, despite attempts to make this an exhaustive inventory, it is possible that a few projects have been overlooked. Finally, projects funded at less than \$5,000 were not included in this survey.

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## OVERVIEW

The General Research Corporation (GRC), a subsidiary of Flow General Inc., was contracted by the Electric Power Research Institute (EPRI), the American Petroleum Institute (API), the Edison Electric Institute (EEI), and the Gas Research Institute (GRI) to survey acid deposition-related research sponsored by the private sector. The project, funded equally by the four previously-mentioned organizations, was technically managed by Mr. Jimmie Nelson of API.

GRC staff contacted approximately 230 individuals associated with acid deposition-related research within the private sector. Many of these contacts were supplied by the funding organizations, while others were suggested during the course of telephone conversations, or were already known to the GRC staff. Individuals from the following industries/groups were contacted:

- |                         |                   |
|-------------------------|-------------------|
| • Electric utilities    | • Iron and steel  |
| • Petroleum             | • Environmental   |
| • Gas                   | • Fishing         |
| • Motor vehicles        | • Paints/coatings |
| • Coal                  | • Cement          |
| • Smelting              | • Chemicals       |
| • Paper/forest products |                   |

A list of all organizations contacted is provided in Appendix D: the Contacted Institutions Index.

Acid deposition research projects funded by the private sector address virtually all areas related to the acid deposition phenomena, from emission sources to environmental effects. These projects are performed either internally by the funding entity, by academic institutions, private contractors, or government entities.

In this study, both direct (e.g., acid deposition effects on crops) and indirect (e.g., emissions inventories) acid deposition research studies were addressed. With regard to indirect acid deposition research, the major chemical species related to the acid deposition problem include:

- Sulfur oxides (e.g., sulfur dioxide, sulfate, sulfite)
- Nitrogen oxides (e.g., nitrogen dioxide, nitrate, nitrite)
- Hydrogen ion
- Hydrogen peroxide
- Sulfuric acid
- Nitric acid
- Calcium
- Magnesium
- Sodium
- Potassium
- Ammonia and ammonium
- Chlorine
- Hydrochloric acid
- Phosphate
- Aluminum

Indirect acid deposition research studies involving these species were surveyed. Both direct and indirect acid deposition research is useful to scientists and administrators interested in the acid deposition phenomena; therefore, information was solicited on research in the following areas:

- Emissions (e.g., quantifying  $\text{SO}_2$  sources and amounts)
- Transport (e.g., modeling, trajectory analysis)
- Chemical transformations (e.g., processes transforming  $\text{NO}_x$  emissions to  $\text{HNO}_3$ )
- Removal and deposition (e.g.,  $\text{SO}_2$  deposition rates from the atmosphere)
- Collection and analyses (e.g., monitoring precipitation, dry deposition, and dews, frosts and fogs for acid deposition-related species)

- Environmental effects (e.g., effect of acid deposition on lakes, rivers, groundwaters, forests, crops, man-made materials, and human health)
- Mitigation (e.g., liming)
- Economics
- Legal policy

This document is an inventory of acid deposition research projects funded at a level of \$5,000 or more by the private sector during FY80, FY81, and FY82. For each inventoried project, a description was written, detailing the following:

- Project Title
- Funding Organization(s)
- Project Officer
- Research Organization(s) and Principal Investigator(s)
- Period of Performance
- Funding
- Research Objectives
- Project Description
- (Expected) Output/Delivery Date(s)

Projects were grouped by their research objectives into the following research categories:

- Atmospheric Processes (AP) - Section 1
- Environmental Effects (EE) - Section 2
- Emissions and Monitoring (EM) - Section 3
- Other Projects (OP) - Section 4

Each of the inventoried studies was categorized by its major research objectives into one of the four above-mentioned research categories. A

more detailed Cross-Referenced Subject Index is provided as Appendix A, with the following subcategories for the four main research categories:

- Atmospheric Processes (AP):
  - Physical/chemical transformation processes
  - Wet deposition processes/modeling
  - Dry deposition processes/modeling
  - Atmospheric transport modeling
  - Source apportionment
  
- Environmental Effects (EE):
  - Agricultural crops
  - Forest vegetation
  - Soils
  - Aquatic systems - chemical and physical water properties
  - Aquatic systems - fauna/flora
  - Materials
  - Liming and other mitigatory techniques
  - Ecosystem modeling
  
- Emissions and Monitoring (EM):
  - Emissions - inventories, reduction scenarios
  - Ambient air monitoring - measurements, techniques, instruments
  - Wet deposition monitoring - measurements, techniques, instruments, data analysis
  - Dry deposition monitoring - measurements, techniques, instruments

- Other Projects (OP):

- Economics
- Policy
- Document critiques
- Workshops
- Program development

Also, to aid the reader, Appendix B, the Funding Organization Index, and Appendix C, the Performing Institution Index, were constructed.

Within each of the four research category [e.g., Atmospheric Process (AP)] sections, the projects were categorized alphabetically using the funding organization. For more than one study by the same funding organization, the projects were ordered alphabetically by project title. Co-funded studies were ordered according to the first listed funding organization, and were placed after all non co-funded studies by that funding organization.

One hundred twenty-four projects have been documented in this report. Table 1 depicts the numbers of projects in each research category. Table 2 indicates the number of projects funded/co-funded by various private sector entities.

Since many projects were only indirectly related to acid deposition, funding for indirect research projects was pro-rated as to the portion actually directed to acid deposition research, as determined by GRC and the funding/performing groups. The total sum of 1980, 1981 and 1982 funding for all projects identified was \$18.7 million (see Table 3). Of the \$18.7 million of identified acid deposition-related research sponsored by the private sector, the funding was broken down by year, industry/group, and research category in Tables 4 and 5.

TABLE 1. PROJECTS BY RESEARCH CATEGORY

Research Category	Number of Projects	Percent of Total Number of Projects
Atmospheric Processes (AP)	27	22%
Environmental Effects (EE)	38	30%
Emissions and Monitoring (EM)	43	35%
Other Projects (OP)	16	13%
TOTAL	124	100%

TABLE 2. NUMBER OF PROJECTS FUNDED OR CO-FUNDED BY PRIVATE SECTOR ENTITIES\*

<u>Industry/Group</u>	<u>Number of Projects</u>
Electric utilities	73
Petroleum	22
Motor vehicles	18
Paper/forest products	6
Environmental groups	5
Coal	4
Smelting	3
Fishing groups	3
Gas	1

\*124 different projects were described in this document. However, several projects were co-funded by different industries/interests. For example, the project through which this document was constructed was funded by the electric utility, gas, and petroleum industries. Therefore, the total number of projects listed above will be greater than 124.



TABLE 3. APPROXIMATE FUNDING LEVELS OF ACID DEPOSITION RESEARCH SUPPORTED BY THE PRIVATE SECTOR BY YEAR\*

Year	Funding*
1980	\$3.1 million
1981	\$7.1 million
1982	\$8.5 million
Total	\$18.7 million

\*Funding levels were not available for 9 of the 124 studies.

TABLE 4. FUNDING LEVELS OF ACID DEPOSITION RESEARCH SUPPORTED BY THE PRIVATE SECTOR BY RESEARCH CATEGORY

Research Category	Funding	Percent of Total Funding
Atmospheric Processes (AP)	\$4.2 million	22%
Environmental Effects (EE)	\$8.0 million	43%
Emissions and Monitoring (EM)	\$6.0 million	32%
Other Projects (OP)	\$0.5 million	3%

TABLE 5. APPROXIMATE FUNDING AND PERCENTAGE OF TOTAL (in parenthesis)  
BY INDUSTRY/GROUP AND YEAR

Industry/Group	FY1980 (thousands \$)	FY1981 (thousands \$)	FY1982 (thousands \$)	Total FY1980 through FY1982 (thousands \$)
Electric Utility Industry*	2,620 (85.6%)	5,776 (81.0%)	6,578 (76.9%)	14,974 (80.0%)
Motor Vehicle Industry	57 (1.9%)	416 (5.8%)	1,022 (12.0%)	1,495 (8.0%)
Coal Industry	171 (5.6%)	475 (6.7%)	546 (6.4%)	1,192 (6.3%)
Petroleum Industry	145 (4.7%)	314 (4.4%)	273 (3.2%)	732 (3.9%)
Metal Smelting Industry	30 (1.0%)	102 (1.4%)	33 (0.4%)	165 (0.9%)
Paper Industry	18 (0.6%)	19 (0.3%)	75 (0.9%)	112 (0.6%)
Fishing Groups	8 (0.3%)	14 (0.2%)	7 (0.1%)	29 (0.2%)
Environmental Groups**	8 (0.3%)	12 (0.2%)	--	20 (0.1%)
Gas Industry	-- --	-- --	12 (0.1%)	12 (0.0%)
Total of all Industries/ Groups	3,057	7,128	8,546	18,731

\*funding not available for 6 projects

\*\*funding not available for 3 projects

**SECTION 1**

**ATMOSPHERIC PROCESSES (AP)**

Project Title:

An Examination of Emissions and Their Dispersion from the ASARCO  
Smelter in Tacoma, Washington (AP1)

Funding Organization:

ASARCO, Inc.

Project Officer:

John D. Richardson  
ASARCO  
Department of Environmental Sciences  
3422 South 700 West  
Salt Lake City, Utah 84119  
(801) 262-2459

Research Organization and Principal Investigator:

Mr. John Lague  
Environmental Research & Technology, Inc.  
2625 Townsgate Road  
Suite 360  
Westlake Village, CA 91361  
(805) 497-0821

Period of Performance:

May 1982 through August 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$33,000	

Research Objective:

The objective of the project was to study emissions from the ASARCO smelter in Tacoma, Washington and their meteorology, especially with respect to possible impacting of the Alpines Lake area to the west.

Project Description:

Specific tasks undertaken included:

- Documentation of the prevailing meteorology in the Puget Sound area within 50 miles of the ASARCO Tacoma Smelter.
- Tracking, on a statistical basis, of the path of the emissions from the smelter.

- Determination of whether the emissions from the smelter could travel through the Alpines Lake area and, if so, the quantity of emissions which could reach that area generally and under meteorological conditions prevailing during precipitation events.
- Determination of the theoretical impact such emissions could have on the hydrogen ion input into the Alpines Lake area and resulting pH changes in receiving waters.
- Likewise, determination of the impact other sources in western Washington could have on the hydrogen ion input into the Alpines Lake area and resulting pH changes in receiving waters.

Output/Delivery Date:

A final report was completed in August 1982.

Project Title:

Evaluation and Reporting of Phillips Computer Program Analysis of  
American Petroleum Institute (API) Tracer Data Base (AP2)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Jimmie Nelson  
Environmental Affairs Division  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-6381

Research Organizations and Principal Investigators:

Marshall Attwater  
TRC Environmental Consultants, Inc.  
800 Connecticut Avenue  
East Hartford, CT 06108  
(203) 289-8631

Lloyd Hellums  
Phillips Petroleum Company  
308 H TRW Building  
Bartellsville, OK 74004  
(918) 661-5851

Period of Performance:

February 1982 through October 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$110,000	
				(\$36,667)*	

Research Objective:

The aim of this study was to evaluate and write a report on the  
Phillips mass transfer analyses of the American Petroleum Institute  
(API) tracer data base (see Project AP22).

\*funds related to acid deposition

Project Description:

Microfiche copies of all computer analyses performed by Phillips on the API data base were obtained and evaluated. A final report detailing the computer analyses and their evaluation was produced.

Expected Output/Delivery Date:

A final report is due in October 1982.

Project Title:

An Analysis of the Effects of Western Copper and Lead Smelter Emissions on Acidic Deposition in the Northeastern United States and Southeastern Canada (AP3)

Funding Organizations:

A group of non-ferrous metals companies: Anaconda Copper Company, ASARCO, Inc., The Bunker Hill Company, Inspiration Consolidated Copper Company, Kennecott Corporation, Magma Copper Corporation, and Phelps Dodge Corporation

Project Officer:

James H. Boyd  
Director, Environmental Affairs  
Newmont Services Limited  
P.O. Box M  
San Manuel, AZ 85631  
(602) 385-2201

Research Organization and Principal Investigator:

George M. Hidy  
Environmental Research & Technology, Inc.  
2625 Townsgate Road, Suite 360  
Westlake Village, CA 91361  
(805) 497-0821

Period of Performance:

December 1980 through June 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$72,000		

Research Objective:

The goal of this study was to analyze the potential effects of western smelter sulfur oxide (SO<sub>x</sub>) emissions on precipitation acidity in the northeastern United States and southeastern Canada.

Project Description:

A mathematical model was used to simulate the transport of parcels of air from a starting point in the western United States to deposition sites in the geographical areas of concern (northeastern United States and southeastern Canada). The modeling techniques adopted used currently available technology to assess the influence



of western smelter sulfur dioxide ( $\text{SO}_2$ ) emissions on long-range transported acidic deposition. For modeling, trajectories were selected which, while broadly characteristic of annual wind patterns, would maximize the acidic deposition impact from the western smelter emissions in the areas of interest. A gridded emission inventory of 100 km square grids was developed using the emissions data from the Sulfate Regional Experiment (SURE) (see Project EM18) and the Multi-State Atmospheric Power Production Pollution Study (MAP3S) program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). The model then was used to simulate the movement of an air parcel from grid to grid along six different trajectories where  $\text{SO}_2$  emissions from both the smelter and non-smelter sources would be accumulated within the parcel. Simulations were run to compute maximum ambient  $\text{SO}_2$  and sulfate ( $\text{SO}_4^{2-}$ ) concentrations in the air parcel passing western smelter locations and arriving at selected sensitive water bodies in the northeastern United States and southeastern Canada.

Output/Delivery Date:

A report entitled "Analysis of the effects of western copper and lead smelter emissions on acidic deposition in the northeastern United States and southeastern Canada" was published in June 1981 as Environmental Research & Technology document P-A849-1.

Project Title:

Uncertainty of State-of-the-Art Regional Air Quality Models (AP4)

Funding Organization:

Consolidation Coal Company

Project Officer:

Richard L. Kerch  
Consolidation Coal Company  
1800 Washington Road  
Pittsburgh, PA 15243  
(412) 831-4527

Research Organization and Principal Investigator:

Amiram Roffman  
Energy Impacts Associates  
2400 Ardmore Boulevard  
Pittsburgh, PA 15221  
(412) 351-5800

Period of Performance:

June 1981 through 15 January 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$23,000		

Research Objective:

The objective of this project was to examine in detail the uncertainty inherent in three long-range transport models.

Project Description:

Three long-range transport models (ENAMAP 1, RCDM, OME-LRT) were examined with respect to their sensitivity to various input parameters as a function of downwind distance (50 km, 100 km, 500 km, 750 km, 1000 km, and 1500 km). The input parameters were :

- Sulfur dioxide ( $\text{SO}_2$ ) to sulfate ( $\text{SO}_4^{2-}$ ) conversion rate.
- $\text{SO}_2$  dry deposition rate.
- $\text{SO}_2$  wet deposition rate.
- $\text{SO}_4^{2-}$  dry deposition rate.

- $\text{SO}_4^{2-}$  wet deposition rate.
- Diffusivity.
- Wind speed.

The magnitude of uncertainty in each model was estimated with respect to the variation in value of each of the input parameters. Finally, the uncertainty due to the joint sensitivity was estimated for each model.

Output/Delivery Dates:

The final report was supplied to Consolidation Coal on 15 January 1982. The findings are also described in Paper No. 82-10.2, entitled "On the Uncertainties of Regional Air Quality Models" by A. Roffman, M.W. Chandler, and R.L. Kerch and presented at the New Orleans APCA Meeting during June 1982.

Project Title:

Cloud Chamber Study of Nitrogen Oxide (NO<sub>x</sub>) Reactions in Cloud Droplets (AP5)

Funding Organizations:

Coordinating Research Council, Inc., with financial support provided on a 50/50 basis by the American Petroleum Institute (API) and the Motor Vehicle Manufacturers Association

Project Officer:

Robert A. Gorse, Jr.  
Ford Motor Company  
Scientific Research Laboratories  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 323-1719

Research Organization and Principal Investigator:

David F. Miller, Director  
Air Resources Laboratory  
Desert Research Institute  
Atmospheric Sciences Center  
P.O. Box 60220  
Reno, NV 89506  
(702) 972-1676

Period of Performance:

August 1980 through April 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$32,300	\$64,600	\$127,200	\$46,300

Research Objectives:

In August 1980, the Desert Research Institute (DRI) began to investigate the parameters that influence the chemical reactions between gaseous nitrogen oxides (NO<sub>x</sub>) and cloud droplets using a laboratory cloud chamber capable of simulating some atmospheric conditions of contamination and cloud formation. The goal is to learn the details of the reaction processes and to determine their importance in the real atmosphere for generating components related to acidic deposition.

Project Description:

The first-year study correlated the change in conversion rates of nitrogen dioxide ( $\text{NO}_2$ ) to aqueous nitrate ion ( $\text{NO}_3^-$ ) in response to changing concentrations of  $\text{NO}_2$ , ozone ( $\text{O}_3$ ), hydrogen peroxide ( $\text{H}_2\text{O}_2$ ), and sulfur dioxide ( $\text{SO}_2$ ); changing cloud droplet pH; and changing the chemical composition of the cloud condensation nuclei (CCN). As a continuation of this work, the second-year study will seek to obtain further information on rapid oxidation reactions in the cloud simulation chamber and in bulk water.

Expected Output/Delivery Dates:

Final report on first-year work, "Kinetics and Mechanisms of  $\text{NO}_x$  Reactions in Cloud Droplets and Their Importance to Precipitation pH," published May 1982.

Final report on second-year work on  $\text{NO}_x$  Reactions in Cloud Droplets, to be published April 1983.

Project Title:

Estimating Regional Air Pollution Impact Potential Using Trajectory  
Analysis (AP6)

Funding Organization:

Detroit Edison Company, Engineering Research Department

Project Officer:

Michael F. Rodenberg  
Detroit Edison Company  
2000 Second Avenue  
Detroit, MI 48226  
(313) 897-1327

Research Organization and Principal Investigator:

Perry J. Samson  
Department of Atmospheric and Oceanic Science  
2455 Hayward  
University of Michigan  
Ann Arbor, MI 48109  
(313) 764-3335

Period of Performance:

1 September 1980 through 30 June 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$24,600	\$45,300	\$19,700	

Research Objectives:

The research objectives of this project were:

- To determine the relative long range transport impact of a single Michigan power plant in terms of sulfur wet and dry deposition, ambient sulfur dioxide (SO<sub>2</sub>) and ambient sulfate (SO<sub>4</sub><sup>2-</sup>).
- To develop sensitivity testing of long range transport model parameterization.
- To compare various locations in the eastern United States and Canada for differences in predicted impact.
- To attempt to validate prediction results with monitored data.

### Project Description:

The following tasks, indicated by year, were undertaken:

- 1980
  - Pollutant transport trajectories and probability fields were computed using 1977 data.
  - A wet deposition scheme was developed.
  - Dry deposition and chemical conversion schemes were developed.
  - Impact fields were determined.
- 1981
  - Sensitivity analysis of parameters influencing long range transport was undertaken.
  - The overall analysis was continued with 1976 and 1978 data.
  - Back trajectories from sampling locations were computed for source apportionment.
  - Results were compared to those determined for other point sources in region.
  - Possible impacts for sensitive regions were compared and interpreted.
- 1982
  - Data were summarized and interpreted.

### Output/Delivery Dates:

Phase I final report, June 1982  
Phase II final report, June 1982  
Phase III final report, September 1982

Project Title:

Acid Deposition/Forest Canopy Interactions (AP7)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

John Huckabee  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2589

Research Organization and Principal Investigator:

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Oak Ridge National Laboratory  
Environmental Sciences Division  
Oak Ridge, TN 37830  
(615) 574-7857

Period of Performance:

1 April 1981 through 31 March 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$149,131	\$194,058	\$208,542*

Research Objective:

The objective of the project is to determine the mechanisms and rates of interactions among precipitation, dry deposition, and airborne pollutants within the deciduous forest canopy.

Project Description:

The approach taken includes both field research (at the Oak Ridge National Laboratory's Walker Branch Watershed site and at the Tennessee Valley Authority's Camp Branch experimental watershed) and controlled exposure studies. Three specific tasks will be undertaken to meet the project objective:

\*planned funds



- Task 1. Field Research - Walker Branch Watershed.  
Concentration profiles of suspended and deposited particles will be collected at either of two closely located sites at points 10m above the surrounding canopy, at three closely spaced intervals within the canopy, at 5m below the canopy, and at ground level. Suspended particles will be collected with air filters and deposited particles with deposition plates. Sampling will be carried out under selected meteorological conditions and during several stages of canopy development: leafless, budbreak, early canopy development, and full canopy. Meteorological conditions with respect to wind speed, wind direction, and atmospheric stability will be monitored.

The deposition plate technique of collecting dry deposition particles will also be used to determine dry deposition rates to inert surfaces. These rates will be compared with deposition rates determined for vegetation surfaces. Upward-facing plates placed in the canopy will collect both impacted and sedimented particles, while downward-facing plates will collect primarily impacted particles.

The problem of collected particle comparability between inert and vegetation surfaces will be addressed by removing surface-deposited particles from leaves by washing the surfaces in distilled water on a reciprocating shaker. Leaves adjacent to the deposition plates will be washed (without removal from the tree) at the start of an exposure-period using a stream of distilled water. Following the exposure period these same leaves will be similarly washed, with the leachate subsequently analyzed to determine the net increase in surface soluble components on the vegetation during this period. The net increase can be related to the exposure period and the leaf surface area to calculate a deposition rate (e.g.,  $\mu\text{gm}^{-2} \text{ day}^{-1}$ ), which may be compared to the deposition rates measured to the inert surface and to those estimated from whole leaf washing.

Six HASL wet/dry deposition samplers will be used for collection of precipitation. All precipitation and throughfall samples will be collected on an event basis and will represent wetfall-only samples. The six HASL collectors will be deployed in different arrangements for two separate tasks. One sampler will be located in an open area on the northwestern edge of the watershed to collect incident precipitation. For the first task, the remaining collectors will be positioned at different distances between the upper canopy and the forest floor at one tower site, using platforms extending into the canopy. This will allow collection of throughfall following the interception of incoming rain by successively greater numbers of leaves and branches. For the

second task, the throughfall collectors will be located throughout the watershed beneath five different canopy types, representing major forest species in Walker Branch. During each period, throughfall and incident precipitation samples will be collected simultaneously on an event basis.

Selected precipitation events will also be sampled for short-term, within-event variations in acidity and nutrient content of incident rain and throughfall.

- Task 2. Controlled Exposure Studies. Branches and foliage selected from upper-canopy levels of forest trees will be used in the laboratory to measure uptake and transformation of gaseous pollutants. Samples collected from the field will be exposed to sulfur dioxide ( $\text{SO}_2$ ), ozone ( $\text{O}_3$ ), and nitrogen oxides ( $\text{NO}_x$ ) in the laboratory using recently developed CSTR (Continuously Stirred Tank Reactor) chambers. These chambers allow control of light, humidity, and temperature, as well as an internal air circulation system ensuring good mixing and minimum leaf boundary layer resistance. Measurements of the processes of dry deposition and transformation of pollutants on foliar surfaces will be accomplished by measuring changes in pollutant concentrations within the test chambers and by following changes in surface-deposited materials which are leachable in a subsequent recovery step. Uptake of pollutants by foliage within the chambers is determined by measuring concentration differences between supply and exhaust air to the chambers (corrected for absorption by empty chambers). Tests will consist of comparisons of uptake by foliage either washed to remove deposited materials or unwashed as collected from the field. Differentiation between physiological uptake and surface deposition of this same foliage will be made by comparing uptake in the light and in the dark following stomatal closure. Experiments in the dark will also permit the kinetics of absorption to be followed by varying both pollutant concentrations and exposure duration. Absorptivity of  $\text{SO}_2$  by wetted foliar surfaces will also be examined to determine the role of dew formation in contributing to surface deposition of sulfur on leaves. Transformation of  $\text{SO}_2$  to sulfate ( $\text{SO}_4^{2-}$ ) in the experimental chambers will be examined by comparing changes in  $\text{SO}_4^{2-}$ /total sulfur ratios following exposures of foliage to  $\text{SO}_2$ .
- Task 3. Watershed Comparison Study. Sulfate deposition data collected on the two watersheds as part of another project will be compared and analyzed both in terms of total input and distribution by process, as well as atmospheric conditions during the sampling period. These data will also be compared to throughfall bulk precipitation, dry HASL samples, and

gaseous sulfur concentrations collected for other tasks of  
this and other ongoing projects.

Expected Output/Delivery Date:

Final report, March 1984

Project Title:

Atmospheric Chemistry Related to the Formation of Acid  
Precipitation (AP8)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Glenn R. Hilst  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2591

Research Organization and Principal Investigator:

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Laboratory Director  
Central Electricity Research Laboratories  
Kelvin Avenue  
Leatherhead, Surrey  
KT 22 7SE United Kingdom  
9-011-44-3723-74488

Period of Performance:

1 April 1978 through 27 January 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$577,000	\$387,000	\$777,000		

Research Objectives:

This project's research objectives were:

- To define the role that power plant emissions, especially sulfur dioxide (SO<sub>2</sub>), play in the formation of acid precipitation.
- To predict what effect reducing SO<sub>2</sub> emissions would have on the acidity of precipitation which falls at great distances (hundreds of kilometers) from the SO<sub>2</sub> source.

### Project Description:

The research entailed an aircraft sampling program along a plume from England, across the North Sea, and to a point of rainfall in Norway. Samples were taken back and forth across the plume--in, above, and below clouds. Gas, cloudwater, and solid samples were taken. Emphasis was placed upon monitoring changes in the chemistry of cloud water along the path of the plume.

Through such a program, the effect of the plume constituents on the chemistry of cloud water can be assessed. Also, through data analysis and modeling, the effect on rain composition of reduced SO<sub>2</sub> emissions can be evaluated. The program involved a number of sophisticated and novel techniques (e.g., sampling water droplets, cryogenic sampling, and use of pulses of freons of different composition in order to identify specific parcels of air).

The research consisted of two phases, with a total of six tasks:

#### Phase I - Development

- Task 1. Cloud Droplet Collecting Devices. A collector for separating cloud water droplets from the air stream was developed. As a back-up, a funnel impactor was simultaneously developed.
- Task 2. Assembling and Testing the Instrument Package. This task involved the assembling in a Lockheed C-130 of equipment for the following purposes: (1) analyzing cloud water; (2) gas sampling; (3) particle sampling; (4) measuring solar radiation; and (5) measuring tracer (freon) concentrations.
- Task 3. Cryogenic Sampling. A liquid helium-cooled sampling device was developed, the purpose of which was to "quench" samples for later laboratory analysis.
- Task 4. Proving Flights. Field tests of the above equipment were undertaken.

#### Phase II - Flight Program

- Task 5. Experimental Flights. Sampling entailed collecting gas, liquid and solid materials in, above, and below clouds. Traverses were made back and forth across a plume from its origin in England, across the North Sea, to a point of rainfall in Norway. The aircraft work was coordinated with precipitation sampling on the ground in Norway.
- Task 6. Data Analysis and Modeling. By monitoring changes in water chemistry, the effects of plume components on acidity

were assessed. By incorporating transformation mechanisms into existing transport models, the effect on acidity of reduced SO<sub>2</sub> emissions was evaluated.

Output/Delivery Dates:

All reports were received from Central Electricity Research Labs by July 1982.

Project Title:

Cloud Model Application to Identify Important Chemical Mechanisms  
(AP9)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Peter K. Mueller  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
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Research Organization and Principal Investigator:

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Richland, WA 99352  
(509) 375-6161

Period of Performance:

2 June 1981 through 30 September 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$37,000	\$33,000	

Research Objectives:

Regional models currently are being developed which relate utility emissions to the occurrence of acid precipitation. However, before such models can be developed and used, the important complex physio-chemical mechanisms which occur in the atmosphere must be identified and parameterized, i.e., put in the form of simple mathematical expressions. This project addressed identification and parameterization of mechanisms for the specific problem of cloud chemistry, with the following overall objectives:

- To use a module model to identify important mechanisms.
- To parameterize those mechanisms for use in more complex regional models which are under development.

The specific parameters of interest were the complex physio-chemical mechanisms which lead to the formation of sulfates ( $\text{SO}_4^{2-}$ ), nitrates ( $\text{NO}_3^-$ ), and other acid-forming substances which are found in acid precipitation.

#### Project Description:

This project consisted of the following tasks:

- Task 1. Thermodynamic and Wind-field Analysis. Using data from the April 1981 OSCAR (Oxidation and Scavenging Characteristics of April Rains) project co-sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy, individual rain bands were analyzed to select the appropriate choice of thermodynamic surfaces. Trajectories and thermodynamic surfaces were determined from wind, temperature, and humidity data for each rain band investigated.
- Task 2. Development of the Appropriate Kinetics/Scavenging Modules. Alternative mechanisms for reactive and non-reactive scavenging of  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ , and  $\text{Cl}^-$  were prepared in subroutine form. These mechanisms included:
  - Direct capture of  $\text{SO}_4^{2-}$  particulate.
  - Direct capture of  $\text{HNO}_3$ .
  - Reactive capture of peroxyacetylnitrate (PAN) to form  $\text{NO}_3^-$ .
  - Capture of  $\text{SO}_2$  with oxidation by ozone ( $\text{O}_3$ ), hydrogen peroxide ( $\text{H}_2\text{O}_2$ ), and  $\text{O}_2$  (catalyzed).
  - Direct capture of  $\text{HCl}$ .
  - Direct capture of  $\text{Cl}^-$  particulate.

Rate and equilibrium relationships for these mechanisms were based upon values reported in the literature and/or obtained through interaction with ongoing theoretical and laboratory work of others.

- Task 3. Application of Model and Data Analysis. The model was tested against the data obtained from each rain band. Alternative mechanisms developed in Task 2 were evaluated and the results of the model runs presented in graphical and numerical form. Parameterization of the pertinent scavenging processes was undertaken.
- Task 4. Project Management and Reporting. The final report summarized the findings of this work, containing the final computer runs presented in graphical and numerical form. Recommendations with regard to future application of the model



and parameterization of the pertinent scavenging process for use in establishing regional models were also presented.

Output/Delivery Date:

A final report was delivered on 31 August 1982.

Project Title:

Incorporation of Acids into Cloudwater (AP10)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Peter K. Mueller  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2586

Research Organization and Principal Investigators:

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Period of Performance:

1 July 1981 through 30 June 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$315,000	\$571,000	1,784,000*

Research Objective:

The objective of this project is to evaluate the processes by which cloud water attains its acidity.

Project Description:

This project will attempt to meet this objective by:

- Determining the extent to which different types of clouds accumulate acidic species.
- Measuring the concentrations of nitrogen and sulfur species in the air within and about these cloud types.

\*planned funding

- Comparing actual concentrations of these species with concentrations predicted from equilibrium theory.
- Measuring the concentrations of oxidants [e.g., ozone ( $O_3$ ) and hydrogen peroxide ( $H_2O_2$ )] that may play a role in the aqueous phase oxidation of sulfur oxides ( $SO_x$ ) and nitrogen oxides ( $NO_x$ ) to sulfuric ( $H_2SO_4$ ) and nitric acids ( $HNO_3$ ) and using these concentrations to establish reaction rates.

In addition to field measurements, the project will include instrumentation development, supporting laboratory experiments, and analysis of collected data. The following tasks will be performed:

- Task 1. Instrumentation. This task will include both installation and testing of instruments on the aircraft and the development and eventual installation and testing of improved instruments.
- Task 2. Scoping Measurements. A limited number of flights will be flown the first year to establish measurement capability, to provide information to design future systematic studies of non-precipitating stratiform clouds, and to demonstrate the feasibility of performing all components of an overall mission. Additional scoping measurements will be performed, as needed, in subsequent years on simple non-precipitating cumuliiform and precipitating stratiform clouds.
- Task 3. Preliminary Analysis and Experimental Design. A preliminary analysis of the measurements obtained under Task 2 will be made to obtain a preliminary characterization of the cloud systems, to assess the spatial variability of chemical species concentrations, and to demonstrate the use of these measurements in determining chemical equilibria and aqueous-phase reaction rates. This analysis will then be used to formulate the design of the systematic set of field measurements to be conducted under Task 4.
- Task 4. Prime Measurements Program. Upon successful completion and approval of the experimental design in the first year of study, this task will implement that design and conduct a systematic series of field experiments to measure the concentrations of species of concern in cloud liquid water and interstitial air, and in the gas and particulate phase in surrounding clear air. The data set obtained will be representative of seasonal and limited geographical variability. The cloud systems of interest will be non-precipitating stratiform, simple non-precipitating cumuliiform, and precipitating stratiform in the second, third, and fourth years of the study, respectively.

- Task 5. Data Analysis and Interpretation. The measurements obtained under Task 4 will be used to:
  - Describe the spatial distribution of chemical species and meteorological variables for each mission.
  - Examine the relation of cloud-water composition to concentrations of gas and particulate phase species and meteorological variables.
  - Evaluate the conformance with or departure from established phase and chemical equilibria.
  - Evaluate the rates of the mechanisms whereby acidic forming species are incorporated into cloud water.
- Task 6. Laboratory Studies. A limited series of laboratory kinetic and mechanistic studies will be performed on reactions for which literature data are either absent or inadequate to evaluate rates under observed field conditions. One reaction identified for investigation at this time is the oxidation of  $\text{HSO}_3^-$  to  $\text{SO}_4^{2-}$  by  $\text{NO}_2$ .
- Task 7. Program Management. This task involves the day-to-day management of the project, preparation of reports, interaction with EPRI, and, most importantly, interaction with researchers doing related work for the purposes of incorporating the latest information on this topic.

Expected Output/Delivery Dates:

Interim reports are to be published at the end of March 1983, with the final report due 30 June 1985.

Project Title:

Modeling of Dry Deposition of Sulfur Dioxide (SO<sub>2</sub>) and Sulfate  
(SO<sub>4</sub><sup>2-</sup>) Aerosols (AP11)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Glenn R. Hilst  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2591

Research Organization and Principal Investigator:

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Aeronautical Research Associates of Princeton, Inc.  
50 Washington Road  
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(609) 452-2950

Period of Performance:

16 April 1978 through 30 July 1980

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$140,000	\$14,000			
	(\$105,000)*	(\$10,500)*			

Research Objectives:

The objectives of this project were:

- To provide a comprehensive understanding of the rates at which airborne pollutants are deposited on the earth's surface.
- To translate this understanding into mathematical forms which could be incorporated into regional air quality models.

\*funds related to acid deposition

- To evaluate experimental measurements required to correctly predict deposition losses.

Project Description:

This project was a theoretical evaluation of the properties of gases and particles and of atmospheric processes which control the dry deposition of pollutants to underlying surfaces. After a brief review of the literature, a model was formulated and calculations were made for four flow regimes: the outer boundary layer, the constant flux region, within the vegetative canopy, and the viscous sublayer next to a leaf or other smooth surface. The results of a number of calculations were presented to demonstrate the sensitivity of deposition to such variables as atmospheric stability, surface resistance, plant area density, plant structural shape, aerosol particle size, Rossby number, and canopy Reynolds number. A relatively simple parameterized model suitable for the Sulfate Regional Experiment (SURE) regional model (see Project EM18) was constructed. Recommendations were made for experiments to address remaining uncertainties.

Output/Delivery Date:

A final report, entitled "Modeling of Dry Deposition of SO<sub>2</sub> and Sulfate Aerosols," was published in July 1980 as Electric Power Research Institute (EPRI) document EA-1452.

Project Title:

Nitrogen Oxide (NO<sub>x</sub>) Transformation in Power Plant Plumes (AP12)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Glenn R. Hilst  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2591

Research Organization and Principal Investigator:

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Battelle Columbus Laboratories  
505 King Avenue  
Columbus, OH 43201  
(614) 424-5014

Period of Performance:

5 July 1978 through 31 December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$230,000	\$207,000	\$150,000	\$163,000	\$960,000**
	(\$34,000)*	(\$31,000)*	(\$22,500)*	(\$24,500)*	(\$144,000)*,**

Research Objective:

The objective of this research is to investigate and document key reactions of nitrogen oxides (NO<sub>x</sub>) as they are emitted from fossil fuel electric generating plants and dispersed in the atmosphere, with particular emphasis placed on identifying and quantifying reactions which lead to the production of nitrates (NO<sub>3</sub><sup>-</sup>) and nitric acid (HNO<sub>3</sub>).

\*funds related to acid deposition

\*\*planned funding

### Project Description:

In a succession of reaction chamber experiments, key reactions and their reaction rates were measured, then tested in simulations of real plume conditions. These results were incorporated in chemical kinetic models for predicting the environmental impact of power plant  $\text{NO}_x$  emissions. The following specific tasks were performed:

- Task 1. Detailed Research Plan Formulation. From a literature search, prior contractor experience, and existing inventories of power plant  $\text{NO}_x$  emissions, key reaction mechanisms for the study were identified.
- Task 2. Chamber Experiments. Using the flow reactor tube and smog chamber at Battelle Columbus Laboratories, systematic studies of key reactions involving nitrogen compounds and other reactants to produce  $\text{NO}_3^-$  and  $\text{HNO}_3$  in power plant plumes were investigated, with special attention given to establishing reliable reaction rate constants.
- Task 2a. Aircraft Measurements of Nitrogen Compounds and Products in Plumes. Using the smog chamber results as experimental guidelines, an instrumented aircraft was used during an intensive measurement period of the Plume Model Validation Project (PMV). These results were compared with chamber results as further guidelines for chamber experiments.
- Task 3. Chemical Kinetic Modeling. Using the results of Task 2 and other appropriate inputs, improved chemical kinetic models were developed which could be incorporated in local and regional atmospheric dispersion and chemistry models for the prediction of the composition and abundance of ambient nitrogen compounds derived from power plant emissions.
- Task 4. Reporting. Quarterly progress reports were produced, highlighting significant findings and desirable changes in the direction of the research. The final report will include a comprehensive report of findings and computer codes for the resulting chemical kinetics models.

### Expected Output/Delivery Dates:

An interim report was published in January 1982. The final report was due in September 1982.



Project Title:

Sulfur Dioxide (SO<sub>2</sub>) Dry Deposition (AP13)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

John Huckabee  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
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Research Organization and Principal Investigator:

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Environmental Transport Division  
Savannah River Laboratory  
E.I. Dupont de Nemours and Company  
Aiken, SC 29801  
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Period of Performance:

23 September 1982 through 1 May 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$110,750	\$221,500
				(\$83,062)*	(\$166,125)*

Research Objectives:

Experiments will be carried out to:

- Measure dry deposition of sulfur dioxide (SO<sub>2</sub>) to a forest using a combination of atmospheric and chamber measurements.
- Measure leaching rate of sulfur that was originally absorbed as SO<sub>2</sub> from leaves using <sup>35</sup>S tagging, allowing interpretation of rain gauge samples.

\*funds related to acid deposition

- Use results to provide critical parameters to a model of sulfur deposition from  $\text{SO}_2$  which will be used to evaluate this flux in sulfur budget studies.

#### Project Description:

The specific tasks used to fulfill the above-mentioned objectives are detailed below:

- Task 1. Dry deposition to vegetation and soil. Two means of measuring  $\text{SO}_2$  deposition to vegetation will be used: the flux gradient method and the branch-soil chamber method.

Chambers will be placed and air pumped through the chambers. After a period of adjustment of 15 to 30 minutes, input and output air samples will be taken in teflon bags for 30 to 60 minutes. During the adjustment and sampling period, the chamber will be exposed to unlabeled  $\text{SO}_2$  at the level desired for exposure. After the sampling period the input and output samples will be analyzed for water vapor added by transpiration and  $\text{CO}_2$  changes caused by net photosynthesis. Then a branch in the chamber will be exposed to labeled  $\text{SO}_2$  for a period of 5 minutes. After labeling, a needle sample will be frozen in dry ice and kept frozen until laboratory analysis for labeled sulfur. The  $\text{CO}_2$  and water vapor concentration of the samples will be measured during the same day, between exposure periods.

To measure  $\text{SO}_2$  deposition to soil, chambers will be placed at appropriate locations and labeled  $\text{SO}_2$  introduced. Ten to fifteen soil deposition measurements per month will be taken. Deposition will be measured as labeled S added to soil after exposures and analysed to measure  $^{35}\text{S}$  volatilized from soil. Soil uptake of  $\text{SO}_2$  will be measured by adding labeled sulfur in one dose. Air samples will be removed at intervals (15 minutes to 1 hour) after exposures varying from one hour to 24 hours. Also, a soil core will be removed, frozen in the field, and later sampled for labeled sulfur in the laboratory.

- Task 2. Leaching of sulfur from vegetation. The branch tips of trees will be labeled with  $^{35}\text{S}$  described in the plant uptake experiment. After labeling, the leaching rate will be determined in three ways.
  - One branch tip will be washed with artificial rain and samples of rain dripping from the branch will be collected at intervals after washing.
  - One branch will have a funnel under it to collect natural rainfall dripping off the branch.

- Needle samples will be taken at intervals after exposure from a number of branches and the labeled sulfur concentrations will be determined.
- Task 3. Model Development. A model will be developed for estimation of SO<sub>2</sub> deposition, based on physical and physiological principles. Model estimates will be evaluated when resistances are known from the detailed measurements. Additionally, the model will be evaluated when the resistances are estimated on the basis of relationships with environmental variables that are developed by analyzing the data from the experiments. Other sites of intensive watershed experiments may provide some of the data necessary to use the model with resistances calculated from environmental variables, such as light, temperature, humidity, etc.

Error analysis will be made of estimates of the deposition as made from:

- The resistances calculated from the measurements made during the experiment.
- The resistances calculated from relationships between the resistances and environmental data.
- Grosser estimates of the resistances similar to what can be expected in the published literature. The third category will include estimates of deposition based on single, seasonal average values of each of the resistances and similar very simple estimates of the resistances.

Expected Output/Delivery Dates:

Quarterly technical reports will be issued to the funding organization, as well as annual summary reports. The draft final report is due 2 months prior to the end of the project.

Project Title:

The Effects of Aerosols and Cloud Droplets on Nighttime  
Transformations of Sulfur Oxides (SO<sub>x</sub>) (AP14)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Peter K. Mueller  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
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Research Organization and Principal Investigator:

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Desert Research Institute  
P.O. Box 60220  
Reno, NV 89506  
(702) 972-1676

Period of Performance:

1 November 1978 through 30 April 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$244,000	\$178,000	\$221,000	\$396,000	\$1,680,000**
	(\$85,400)*	(\$62,300)*	(\$77,350)*	(\$138,600)*	(\$840,000)*,**

Research Objectives:

The main objective of this research is to measure the conversion rates of sulfur dioxide (SO<sub>2</sub>) to sulfate (SO<sub>4</sub><sup>2-</sup>) under a variety of nighttime atmospheric conditions. A second objective is to test theoretical kinetic models to assess their relevance to atmospheric conditions. A third objective is to measure the modification of particles, especially the changes in their chemical composition, size, and properties for absorbing light and water, caused by in-cloud processes.

\*funds related to acid deposition

\*\*planned funding

### Project Description:

The approach used in meeting these objectives was to: (1) adapt the existing Desert Research Institute (DRI) dynamic cloud chamber for experimental studies of homogeneous and heterogeneous reactions of  $\text{SO}_2$  under nighttime reactive conditions, (2) develop and demonstrate systems for the collection and analysis of cloud droplets which exclude interstitial particles, (3) measure the conversion rates of  $\text{SO}_2$  to  $\text{SO}_4^{2-}$  under a variety of temperature, humidity, and liquid water conditions and under systematic variations of reactants and catalytic materials, and (4) analyze the experimental data in terms of chemical kinetic rate constraints and the relative importance of various chemical and physical mechanisms in  $\text{SO}_4^{2-}$  formation.

A detailed project description includes the following tasks:

- Task 1. System Set-Up and Testing. (completed)
- Task 2. Experimentation and Data Collection. (completed)
- Task 3. Data Reduction and Assessment. (completed)
- Task 4. Development and Test of Advanced Characterization Equipment. An instrument to measure aerosol critical super saturation and size distribution was developed and tested prior to this investigation. The appropriate interfacing and testing were provided so that the instrument could be used in the cloud chamber experiments. A cloud droplet impactor to measure the size distribution was developed, installed, and tested. The cloud droplet impactor was modified to simultaneously measure cloud water pH. (completed)
- Task 5. Installation and Testing of New  $\text{SO}_2$  Monitor and Clean Air System. A new  $\text{SO}_2$  monitor was installed and tested so that  $\text{SO}_2$  measurements could be made continuously throughout an experimental run. A new air purification system was installed in order to improve reproducibility of results by avoiding contamination problems. (completed)
- Task 6. Haze and Cloud Condensation Nuclei (CCN) Modification Experiments. Experiments were performed to determine the rate of  $\text{SO}_2$  oxidation in haze and measurement changes in the critical supersaturation spectrum and chemical composition of the CCN. The independent variables tested included relative humidity,  $\text{SO}_2$  concentration, initial cloud condensation nuclei composition and pH, catalysts (i.e.,  $\text{Mn}^{+2}$  and  $\text{Fe}^{+2}$ ), and aging to reaction time. (completed)

- Task 7. Feasibility Experiments on Effects of Hydrochloric Acid (HCl) on SO<sub>2</sub> Oxidation. A limited series of experiments were performed to investigate the effect of HCl on SO<sub>2</sub> oxidation. (completed)
- Task 8. Characterization of Concentrated Buffer CCN. Improved size distribution characterization of the concentrated buffer cloud condensation nuclei produced by nebulization was performed. The results allowed more accurate information and control of the initial size distribution of cloud condensation nuclei in the buffered cloud experiments of Task 9. (completed)
- Task 9. Buffered Cloud and Interstitial Particle Scavenging Experiments. Experiments will be performed to determine the rate of SO<sub>2</sub> oxidation in buffered cloud droplets and to determine the effect of interstitial particle scavenging on the oxidation rate in unbuffered cloud droplets. The independent variables to be tested will include initial cloud droplet pH, SO<sub>2</sub> concentration, catalysts, and cloud condensation nuclei size distribution and chemical composition. (to be completed by 31 October 1982).
- Task 10. Data Analyses, Project Coordination and Management, and Reporting. The experimental results will be analyzed continuously in order to make decisions during the project as to whether or not to proceed with a given line of investigation. Subsequent experimental runs will be selected based on previous results and theoretical considerations. It is anticipated that the results of this program will provide insight into:
  - How the independent variables affect the kinetics of SO<sub>2</sub> oxidation in clouds and haze.
  - The upper limit of the rate of SO<sub>2</sub> oxidation under nighttime conditions.
  - The extent to which particulates are physically and chemically modified by cloud growth and evaporation cycles.

This task is to be completed by 31 March 1983.

Expected Output/Delivery Dates:

Reports (quarterly, annual, final)  
Published papers from principle investigators

Project Title:

Winter Precipitation Chemistry Study (AP15)

Funding Organization:

Empire State Electric Energy Research Corporation

Project Officer:

Peter Coffey  
c/o New York Power Pool  
3890 Carmen Road  
Schenectady, NY 12303  
(518) 381-2124

Research Organization and Principal Investigator:

Volker Mohnen  
Atmospheric Sciences Research Center  
State University of New York  
Albany, NY 12222  
(518) 457-4604

Period of Performance:

April 1982 through April 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$112,000	undetermined

Research Objective:

The objective of this project is to determine the mechanisms for acidification of winter precipitation, with compounds of nitrogen, sulfur, and various oxidants to be studied.

Project Description:

Cloudwater, aerosols, and gases in super-cooled clouds will be examined so that in-cloud sulfur dioxide (SO<sub>2</sub>) and nitrogen dioxide (NO<sub>2</sub>) absorption, desorption, and chemical transformation rates may be calculated. The following specific tasks will be undertaken:

- Development of a constant efficiency super-cooled cloud droplet detector.

- Collection of meteorological data during precipitation events, augmented by determination of snow crystalline structure.
- Chemical analyses of collected precipitation.
- Ambient air analyses of species [ $\text{SO}_2$ , nitrogen oxides ( $\text{NO}_x$ ), hydrogen peroxide ( $\text{H}_2\text{O}_2$ ), ozone ( $\text{O}_3$ ), nitric acid ( $\text{HNO}_3$ ), and ammonia ( $\text{NH}_3$ )] that may be active in the acidification processes.
- Employment of air mass trajectory analysis to determine source areas.

Expected Output/Delivery Date:

A final report describing measurement techniques, analytical techniques, actual findings, and conclusions will be produced in mid-1984.



Project Title:

The Relationship of SO<sub>2</sub> Emissions to Sulfur Deposition (AP16)

Funding Organization:

anonymous grant

Project Officer:

not available

Research Organization and Principal Investigator:

M. Oppenheimer  
Environmental Defense Fund, Inc.  
444 Park Avenue, South  
New York, NY 10016  
(212) 686-4191

Period of Performance:

April 1981 through (continuing)

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		not available			

Research Objective:

The purpose of this study was to address the following question:  
if emissions of sulfur dioxide are reduced by a given amount, how  
much reduction will occur in precipitation sulfates?

Project Description:

Precipitation sulfate (SO<sub>4</sub><sup>2-</sup>) is regarded as the most significant source of potential ecosystem acidification in the eastern United States. In this project, the possible mechanisms for formation of SO<sub>4</sub><sup>2-</sup> from sulfur dioxide (SO<sub>2</sub>) emissions were examined. By comparing the observed wet SO<sub>4</sub><sup>2-</sup> deposition in precipitation as determined from 1977-79 National Atmospheric Deposition Program (see Project EM37) data, the fraction of SO<sub>2</sub> emitted which was converted to SO<sub>4</sub><sup>2-</sup> and deposited via precipitation was calculated. Taking into account dry deposition of SO<sub>4</sub><sup>2-</sup> and deposition of SO<sub>2</sub> into oceans, the efficiency of the SO<sub>2</sub> to SO<sub>4</sub><sup>2-</sup> conversion was inferred. Subsequently, the relationship of changes in SO<sub>2</sub> emissions to changes in SO<sub>4</sub><sup>2-</sup> deposition in precipitation was predicted.

Expected Output/Delivery Date:

An article entitled "The Relationship Between Sulfur Emissions and Sulfate in Precipitation" has been accepted for publication by Atmospheric Environment.

Project Title:

Florida Acid Deposition Study  
Source Attribution and Long-Range Transport Program (Program 2 of  
4) (AP17)

Funding Organization:

Florida Electric Power Coordinating Group, Inc.  
402 Reo Street, Suite 214  
Tampa, FL 33609  
(813) 877-5301

Project Officer:

Charles D. Henderson  
Environmental Affairs Department  
Florida Power and Light Company  
P.O. Box 529100  
Miami, FL 33152  
(305) 552-4819

Research Organization and Principal Investigator:

E.R. Hendrickson  
Project Director  
Environmental Science & Engineering, Inc.  
P.O. Box ESE  
Gainesville, FL 32602  
(904) 372-3318

Period of Performance:

January 1981 through March 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$60,000	\$20,000	\$60,000*

Research Objectives:

The Florida Acid Deposition Study's primary objective is to assess and develop information needed to place the acid deposition issue in proper perspective for Florida as to its magnitude, variability, sources, effects, and control options.

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\*planned funding

The study is divided into four study programs (each program is described as a separate project in this document - consult the Funding Organization Index) and four time phases, to allow periodic reassessment of the desirability of continuing funding or changing direction.

The specific objective of the Source Attribution and Long-Range Transport Program is to determine the relative contribution of Florida's electric utility industry to the atmospheric deposition of acidity and related chemical species in Florida and in neighboring states.

#### Project Description:

During Phase I (January through September 1981), evaluation of existing data bases and ongoing programs which have examined the long-range transport of source effluents was undertaken. Potential sources of data for meteorological and source inputs to long-range models were examined. Long-range (800 miles), mid-range (500 miles), and in-state contributions were considered. The utility of the Brookhaven trajectory analysis program was also determined. The cost-effectiveness of trajectory analysis techniques versus transport modeling was evaluated. Level of effort for updating the long-range, short-time interval emission inventory prepared for the Electric Power Research Institute (EPRI) in the Sulfate Regional Experiment (SURE) program (see Project EM18) was estimated, and its utility for evaluation of the Florida monitoring data determined. Finally, the utility and cost-effectiveness of weather radar and multi-altitude trajectory analysis available in Florida was examined with respect to its value in determination of in-state source attribution.

During Phase I, conclusions were developed regarding the potential for success in meeting the program's objectives, based on the level of confidence in the modeling results, as well as the model's overall evaluation. Subsequent phases will be based upon the results of Phase I. During Phase II (October 1981 through September 1982) detailed experiments are being designed for implementation during Phase III. External data and necessary equipment for these experiments are being acquired.

#### Expected Output/Delivery Dates:

As previously stated, the Florida Acid Deposition Study consists of four phases. Phase I started in January 1981 and ended in September 1981. Subsequent phases (as currently planned) are as follows:

Phase II	October 1981 - September 1982
Phase III	October 1982 - September 1983
Phase IV	October 1983 - March 1985

Interim reports will be produced after the completion of each phase. A final report is expected in mid-1985.

Project Title:

Deposition of Acids in Dew and Frost (AP18)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Peter J. Groblicki  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3367

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

October 1981 through June 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$31,250*	\$62,500**

Research Objectives:

This project's objectives are to quantify the role of dew and frost in atmospheric acid deposition and to determine the controlling factors affecting this acidity.

Project Description:

In 1982 two dew/frost collectors will be built: a passive collector for naturally occurring dew and frost, and a chilled teflon coated plate to be used for the production of artificial dews. The following species will be monitored simultaneously with the production of dew: particulate  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$ , strong acidity,  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{O}_3$ ,  $\text{NH}_3$ ,  $\text{HNO}_3$ , and  $\text{H}_2\text{O}_2$ . It is hoped that the determination of these species will provide insight into the controlling mechanisms of dew acidity. In addition the project will:

\*estimated funding

\*\*estimated future funding

- Determine the amount of acid deposition in dew and frost.
- Compare dew and frost composition to that of rain and snow.
- Determine the relative importance of dew and frost compared to rain and snow for acid deposition.

Expected Output/Delivery Date:

A report on 1982 results will be issued late in 1983.

Project Title:

Droplet Reactions Leading to Acid Formation (AP19)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Peter J. Groblicki  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3367

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

March 1982 through (undetermined)

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$93,750*	\$250,000**

Research Objective:

The objective of this research will be to investigate the effects of NO<sub>2</sub>, hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), ozone (O<sub>3</sub>), and other oxidants on the conversion of sulfur dioxide (SO<sub>2</sub>) to acid sulfate (SO<sub>4</sub><sup>2-</sup>) using a laboratory cloud simulator.

Project Description:

In 1982 a flow reactor system capable of generating steady state clouds in a vertical flow tube will be designed. The system will have the capability of introducing various gases to the flow stream

\*estimated funding

\*\*estimated future funding



and a means of collecting the cloud water at varying distances down the tube. Construction and initial verification of the system's operating parameters will be completed in 1982. In 1983 the system will be used to study the effect of  $\text{NO}_2$ ,  $\text{O}_3$ ,  $\text{H}_2\text{O}_2$ , and other species on the oxidation rate of  $\text{SO}_2$  to  $\text{SO}_4^{2-}$  in cloud water droplets.

Expected Output/Delivery Dates:

Not yet determined

Project Title:

Long-Distance Transport of Air Pollutants (AP20)

Funding Organization:

General Motors Research Laboratories

Project Officer:

David P. Chock  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3263

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

April 1982 through (undetermined)

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$62,250*	\$187,500**

Research Objective:

This project's objective will be the establishment of a reliable mesoscale model (not trajectory) to characterize long-distance transport processes in the atmosphere, including dry deposition processes.

Project Description:

Currently, existing mesoscale models are being surveyed and areas of needed improvement identified. In 1983 the most promising mesoscale model will be improved and applied to transport problems. Dry deposition processes will be incorporated.

Expected Output/Delivery Dates:

Not yet determined

\*estimated funding

\*\*estimated future funding

Project Title:

Scavenging of SO<sub>2</sub> and NO<sub>x</sub> by Rain (AP21)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Sudarshan Kumar  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3348

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

March 1982 through October 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$125,000*	\$125,000**

Research Objective:

This project will entail the development of a mathematical model for uptake of sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) by rain and subsequent chemical reactions in the falling droplets.

Project Description:

A mathematical model for the uptake and transformation of SO<sub>2</sub> and NO<sub>x</sub> in droplets will be developed, incorporating these factors:

- Mass transport limitations for scavenging of gases.
- Liquid-phase chemistry:
  - Oxidation of sulfur compounds.
  - Oxidation of nitrogenous compounds.

\*estimated funding

\*\*estimated future funding

- Interactions between sulfur and nitrogen compounds.
  - Effect of trace species on pH and chemistry.
- Collection efficiencies of aerosol particles by rain.

Expected Output/Delivery Dates:

Not yet determined

Project Title:

Computer Program Analysis of American Petroleum Institute (API)  
Tracer Data Base (AP22)

Funding Organization:

Phillips Petroleum Company

Project Officer:

Don Fine  
Phillips Petroleum Company  
7D4 Phillips Building  
Bartellsville, OK 74004  
(918) 661-6600

Research Organization and Principal Investigator:

Lloyd Hellums  
Phillips Petroleum Company  
308 H TRW Building  
Bartellsville, OK 74004  
(918) 661-5851

Period of Performance:

June 1981 through December 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			(\$26,000)		
			(\$8,667)*		

Research Objective:

The goal of this research was to apply mass transfer analysis computer programs to the American Petroleum Institute (API) tracer data base.

Project Description:

The American Petroleum Institute (API) has previously retained TRC Environmental Consultants to amass a large tracer data base of field data on atmospheric dispersion. Mass transfer analysis computer programs were used to analyze this data base. Horizontal ( $\sigma_y$ ) and vertical ( $\sigma_z$ ) mass transfer correlations were obtained for

\*funds related to acid deposition

each data set in the API data base, a data set being one tracer release experiment in a program. Twelve programs from the API data base were selected for analysis. Equivalent Turner stabilities were determined from the mass transfer analyses performed on each data set.

Output/Delivery Dates:

Computer program analysis results were stored on microfiche.

Project Title:

Development of Atmospheric Mass Transfer Analysis Programs (AP23)

Funding Organization:

Phillips Petroleum Company

Project Officer:

Don Fine  
Phillips Petroleum Company  
7D4 Phillips Building  
Bartelsville, OK 74004  
(918) 661-6600

Research Organization and Principal Investigator:

Lloyd Hellums  
Phillips Petroleum Company  
308 H TRW Building  
Bartelsville, OK 74004  
(918) 661-5851

Period of Performance:

January 1979 through December 1980

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$15,000	\$31,000			
	(\$5,000)*	(\$10,333)*			

Research Objective:

The goal of this research was to construct computer programs able to perform rigorous analyses of experimental data to obtain  $\sigma_y$  (horizontal) and  $\sigma_z$  (vertical) mass transfer correlations as used in the Gaussian plume formulation for atmospheric dispersion.

Project Description:

One program was developed for single source point releases and another program developed for multiple point source releases. The programs determined  $\sigma_y$  and  $\sigma_z$  correlations in such a manner as to give optimal fit of Gaussian plume formulation to field data.

\*funds related to acid deposition

Output/Delivery Dates:

The two computer programs were developed by December 1980.



Project Title:

Development of Plant Site Specific Mass Transfer Correlations  
(AP24)

Funding Organization:

Phillips Petroleum Company

Project Officer:

Don Fine  
Phillips Petroleum Company  
7D4 Phillips Building  
Bartellsville, OK 74004  
(918) 661-6600

Research Organization and Principal Investigator:

Lloyd Hellums  
Phillips Petroleum Company  
308 H TRW Building  
Bartellsville, OK 74004  
(918) 661-5851

Period of Performance:

January 1982 through November 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$58,000	
				(\$19,100)*	

Research Objective:

The goal of this study is to analyze atmospheric dispersion from a Phillips Petroleum Company refinery.

Project Description:

Phillips Petroleum Company has obtained field monitor data for two of its refineries. The field monitor data will be analyzed to obtain site specific mass transfer correlations for  $\sigma_y$  and  $\sigma_z$  as used in the Gaussian plume formulation for atmospheric dispersion. Data for one plant is presently being analyzed by Phillips.

\*funds related to acid deposition

Expected Output/Delivery Date:

A final report is due on 31 December 1982.

Project Title:

Atmospheric Dispersion and Interaction in Stack Emissions (AP25)

Funding Organization:

Tennessee Valley Authority, Office of Power

Project Officer:

John B. Brellenthin  
Environmental Support Staff  
Tennessee Valley Authority  
1110 Chestnut Street Tower II  
Chattanooga, TN 37401  
(615) 751-5672

Research Organization and Principal Investigator:

James C. Meagher  
Air Resources Program  
Tennessee Valley Authority  
80C River Oaks Building  
Muscle Shoals, AL 35660

Period of Performance:

1 October 1980 through 30 September 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$115,000	\$134,200	\$497,000**
			(\$34,500)*	(\$40,300)*	(\$149,000)*,**

Research Objectives:

This project has the following research objectives:

- To investigate interactions between power plants and urban plumes that may influence the rate of secondary pollutant [sulfate ( $\text{SO}_4^{2-}$ ), nitrate ( $\text{NO}_3^-$ ), ozone ( $\text{O}_3$ )] formation.
- To demonstrate the effectiveness of different emission control options in reducing secondary pollutant formation.

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\* funds related to acid precipitation

\*\* planned funding

- To investigate effects of different atmospheric conditions (relative humidity, background air quality, solar intensity, temperature) on plume chemistry.

#### Project Description:

This project consists of the following tasks:

- Task 1 (June 1981 - October 1982). Using instrumented aircraft, the plume from the Allen Steam Plant was sampled as it dispersed and mixed with the urban plume from Memphis, Tennessee (8 km northeast of the plant). Gaseous, aerosol, and particulate species [sulfur dioxide ( $\text{SO}_2$ ), nitric oxide (NO), nitrogen dioxide ( $\text{NO}_2$ ),  $\text{NO}_3^-$ ,  $\text{O}_3$ , and hydrocarbons], as well as ambient atmospheric conditions (temperature, light intensity, humidity, wind speed and direction) were measured. Data were analyzed to determine conversion rates and chemical behavior as the plumes mixed.
- Task 2 (Summer 1982 - October 1984). The Tennessee Valley Authority (TVA) has constructed a  $31 \text{ m}^3$  photochemical reaction chamber to simulate atmospheric transformation processes under controlled conditions. Flue gases from an operating coal-fired power plant have been used in previous studies; simulated flue gas mixtures will be used in this series of experiments.  $\text{SO}_2$  and nitrogen oxides ( $\text{NO}_x$ ) concentrations will be varied to simulate different emission control options and to evaluate their effectiveness in reducing secondary pollutant ( $\text{O}_3$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ) formation. Humidity and hydrocarbon levels will each be varied to evaluate their influences on plume chemistry. Instrumentation is available for the monitoring of  $\text{NO}_x$ ,  $\text{O}_3$ , total gaseous sulfur,  $\text{SO}_2$ , carbon monoxide (CO), Aiken nuclei, temperature, humidity, particle size, light scattering, hydrocarbons, and particulates collected on filters.
- Task 3 (October 1983 - October 1984). Formation of intermediate S(IV) species will be studied in smog chamber simulations. Oxidation mechanisms and the identity of intermediate species will be evaluated.
- Task 4 (October 1984 - October 1985). Aircraft sampling to validate chamber results will be undertaken.

#### Expected Output/Delivery Dates:

A final report for aircraft study at Allen Steam Plant was produced in October 1982. A report on smog chamber studies will be completed by October 1984. The final report on chamber studies will be prepared by October 1985.

Project Title:

Dispersion Model Research and Development (AP26)

Funding Organization:

Tennessee Valley Authority, Office of Power

Project Officer:

John B. Brellenthin  
Environmental Support Staff  
Tennessee Valley Authority  
1110 Chestnut Street - Tower II  
Chattanooga, TN 37401  
(615) 751-5672

Research Organization and Principal Investigator:

Timothy L. Crawford  
Air Resources Program  
Tennessee Valley Authority  
73-B River Oaks Building  
Muscle Shoals, AL 35660  
(205) 386-2788

Period of Performance:

1 October 1980 through 30 September 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$120,000	\$170,000	\$213,500	\$839,000**
		(\$40,000)*	(\$50,000)*	(\$64,000)*	(\$252,000)*,**

Research Objectives:

The research objectives of this study are as follows:

- To develop and assess dispersion models for use in predicting the impact of emissions from Tennessee Valley Authority (TVA) coal-fired plants on local, regional, and interregional air quality.

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\*funds related to acid deposition

\*\*planned funding

- To adapt models for specific TVA needs in demonstrating:
  - Maintenance of National Ambient Air Quality Standards (NAAQS).
  - Consumption of prevention of significant deterioration (PSD) increments.
  - Impact to PSD Class I area.
  - Transport of secondary acidic pollutants.

#### Project Description:

This project consists of the following tasks:

- Task 1 (1981). Meteorological input to the Air Resources Regional Pollution Assessment (ARRPA) model from the National Oceanic and Atmospheric Administration's (NOAA) Boundary Layer Model (BLM) was developed. A user's manual for BLM input to the ARRPA model was completed.
- Task 2 (1982). Model evaluation will be performed by intended users and by comparing computed trajectories to those predicted by tracking aerially released tetroons. Sources and degree of bias in modeled trajectories will be estimated.
- Task 3 (1982-1983). Sensitivity analyses will be performed to determine: (1) the effect of error in meteorological input on model output; and (2) the range of meteorological conditions over which the model is applicable.
- Task 4 (1983-1985). Models will be applied using data collected at monitoring stations in the region, at other meteorological stations, and by aircraft sampling. Model performance will be evaluated, deficiencies analyzed, and corrections made. The validated model will be available for application to long-range transport research on sources of acidic deposition in the southern Blue Ridge province.
- Task 5 (1982-1985). This task will consist of documentation of the model program and model performance, conversion of model code to generic computer usage, and documentation of results, future direction, and needs.

#### Expected Output/Delivery Dates:

Model development completed was in October 1982. The user manual will be prepared in 1983. A report on model evaluation and performance will be completed by October 1985.

Project Title:

Wisconsin Acid Deposition Cooperative Research Program  
Trajectory Analysis Research Program (AP27)

Funding Organization: \*\*\*

Wisconsin Utilities Association

Project Officer:

Eric Hennen  
Dairyland Power Cooperative  
2615 East Avenue South  
La Crosse, WI 54601  
(608) 788-4000

Research Organization and Principal Investigator:

David B. Smith  
Charles T. Main, Inc.  
Prudential Center  
Boston, MA 02199  
(617) 262-4153

Period of Performance:

April 1982 through July 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$39,275	\$95,725**
				(\$32,000)*	(\$78,000)*,**

Research Objectives:

The Wisconsin Acid Deposition Cooperative Research Program includes four study programs (each program is described as a separate project in this document - consult the Funding Organization Index), with the following overall objectives:

- To identify sources and levels of acid deposition in Wisconsin.

\*funds supplied by the private sector organization.

\*\*planned funding

\*\*\*non-private sector funding supplied by the Wisconsin Department of Natural Resources

- To quantify susceptible resources and the possible environmental effects of acid deposition.
- To identify and quantify the potential of current control and mitigatory technologies for reducing the potentially adverse effects of acid deposition.

The specific research objectives of the Trajectory Analysis Research Program are to:

- Identify the source regions of acid precipitation precursors [sulfur oxides ( $\text{SO}_x$ ) and nitrogen oxides ( $\text{NO}_x$ )], based upon their meteorological trajectories prior to their deposition in Wisconsin.
- Differentiate to the extent possible in-state versus out-of-state contributions to acid deposition in Wisconsin.

#### Project Description:

This project will be composed of the following tasks:

- Task 1. Assemble complete meteorological data base in conjunction with the Deposition Monitoring Network (see Project EM42). Data collection will include all upper air and surface National Weather Service reporting stations bounded by the Atlantic coast, the Gulf Coast, the Mexican Border, the Continental Divide, and  $55^\circ\text{N}$  latitude.
- Task 2. Calculate air mass trajectories for 30 J.T.R.C. selected precipitation events. Trajectory construction will be either a moist isentropic method (incorporating condensation and vertical motion) or a constant level, mixed layer method (ARL Model). The moist isentropic model will be used when the precipitation is mostly related to large scale storms or perturbations. The ARL model will be used when the precipitation is mostly related to isolated free convection with no significant organized large scale lifting.
- Task 3. Use a case study approach to evaluate trajectory, meteorological, and precipitation chemistry data for each of the 30 above-mentioned precipitation events. Computed trajectories will be plotted on base maps with emission information. Vertical incorporation of surface pollutants into the trajectory parcel will be determined by matching the trajectory height against the mixing depth determination. If the trajectory passes through or within 300 meters of the ground, it is assumed that surface pollutant incorporation into the trajectory parcel has occurred. Chemical analysis



data from the deposition events will then be correlated with the designated surface pollutant incorporation areas.

- Task 4. Use a climatological approach to classify and evaluate the overall meteorological and monitoring data base. Events beyond the 30 for which trajectory analysis is performed will not be analyzed in detail, but all precipitation events will be summarized and correlated with respect to chemical constituent analysis and meteorological factors.
- Task 5. On the basis of the above studies, identify the probable source regions for the precursors of acid precipitation in Wisconsin and, to the extent possible, differentiate in-state versus out-of-state contributions to the monitored acid precipitation.
- Task 6. Implement a quality assurance program, including independent back-trajectory analyses of several of the same events evaluated in Task 3, and review of results.

Expected Output/Delivery Dates:

Not yet determined

**SECTION 2**

**ENVIRONMENTAL EFFECTS (EE)**

Project Title:

Near-Plant Environmental Impacts of Coal-Fired Power Plants (EE1)

Funding Organization:

American Electric Power Service Corporation

Project Officer:

John M. McManus  
Associate Engineer  
American Electric Power Service Corporation  
Box 487  
Canton, OH 44701  
(216) 452-5721

Research Organization and Principal Investigator:

Peter Van Voris  
Battelle Columbus Laboratories  
505 King Avenue  
Columbus, OH 43201  
(614) 424-7579

Period of Performance:

1 September 1981 through 30 October 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$15,000	\$30,000	
			(\$5,000)*	(\$10,000)*	

Research Objective:

The objective of the program is to investigate local variations in litter decomposition, soil chemistry, and heavy metal concentrations in soil, litter, and moss samples collected near a complex of four major coal-fired power plants. The data will be used to assess current local variations among these parameters and provide a baseline against which possible future changes may be measured.

\*funds related to acid deposition

Project Description:

A series of sites along a 70-mile transect through the power plant complex were chosen for collection of soil, litter, and moss samples. To determine possible impacts from deposition of heavy metals and acidic species, these samples are being analyzed for heavy metals, cation exchange capacity, soil pH, organic matter,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ , litter decomposition, and other parameters. Analysis of coal and fly ash is also being conducted to provide a qualitative estimate of power plant emissions.

Expected Output/Delivery Date:

Final report, late 1982

Project Title:

The Biological Effects of Acid Deposition and Heavy Metal  
Deposition on Forest Ecosystems in the Green Mountains of Vermont  
(EE2)

Funding Organization:

American Electric Power Service Corporation

Project Officer:

John M. McManus  
Associate Engineer  
American Electric Power Service Corporation  
Box 487  
Canton, OH 44701  
(216) 452-5721

Research Organization and Principal Investigators:

Richard M. Klein  
Hubert W. Vogelmann  
Department of Botany  
University of Vermont  
Burlington, VT 05405  
(802) 656-2930

Period of Performance:

1 September 1980 through 31 August 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$20,000	\$40,000	\$61,000	\$68,000*

Research Objective:

The objective of the project is to determine if alterations in the structure and composition of the forest ecosystem in the Green Mountains of Vermont, particularly Camels Hump Mountain, are occurring, and if so, whether they are attributable to acid deposition and/or heavy metal deposition.

\*planned funding

Project Description:

An extensive data base dating from the mid-1960's, detailing the floristics, climatology, soils, etc., of Camels Hump Mountain is available. The current research effort consists of using this data base for comparative studies to quantify possible changes over the 20-year period. Specific tasks include:

- Year 1

- Analysis of precipitation and fog for acid and heavy metal content.
- Chemical analyses of soils from 1964 and 1979 for acidity and heavy metals.
- Lab simulations of growth of bacteria, blue-green algae, and mycorrhizal fungi, under various conditions.

- Year 2

- Field/lab studies on forest regeneration and microflora relationships.
- Tree-core analysis to determine trends in growth and heavy metal accumulation.
- Continued analysis of precipitation and soils.

- Year 3

- Completion of field data.
- Field/lab interaction on microflora studies.

Expected Output/Delivery Date:

A series of manuscripts detailing the results of various aspects of the research will be developed, as well as an August 1983 final report.

Project Title:

Updating of Knowledge Concerning Acid Rain (EE3)

Funding Organization:

American Electric Power Service Corporation

Project Officer:

John M. McManus  
Associate Engineer  
American Electric Power Service Corporation  
Box 487  
Canton, OH 44701  
(216) 452-5721

Research Organization and Principal Investigator:

Joseph H. Oxley  
Battelle Columbus Laboratories  
505 King Avenue  
Columbus, OH 43201  
(614) 424-7885

Period of Performance:

1 January 1982 through 30 June 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$125,000	\$100,000	\$90,000	

Research Objectives:

The original program objectives were:

- To determine what is currently known about the formation, transport, deposition, and environmental effects of acid deposition.
- To identify current or planned acid deposition research efforts.
- To determine what additional research efforts are needed to permit rational conclusions and recommendations concerning the environmental effects of acid deposition.

Project Description:

Information was collected through literature searches, interviews, and field visits for the following subject areas:

- Emission sources.
- Chemistry and measurements.
- Atmospheric transport.
- Distribution of acidity.
- Environmental effects.

Output/Delivery Date:

A multi-volume final report, entitled "Third Progress Report to American Electric Power Service Corporation on New Knowledge Concerning Acid Rain," was completed in mid-1982.



Project Title:

Acid Deposition on a Massachusetts Water Supply Watershed: The  
Roles of Biological and Abiotic Buffering on the Bickford Reservoir  
and Watershed (EE4)

Funding Organizations:

American Electric Power Service Corporation  
Consolidated Edison Company  
New England Power Service Company  
Northeast Utilities

Project Officer:

John M. McManus  
Associate Engineer  
American Electric Power Service Corporation  
Box 487  
Canton, OH 44701  
(216) 452-5721

Research Organization and Principal Investigator:

Harold F. Hemond  
Department of Civil Engineering  
Massachusetts Institute of Technology  
Cambridge, MA 02139  
(617) 253-1637

Period of Performance:

1 June 1981 through 31 May 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$39,000	\$70,000	\$26,000*

Research Objectives:

Research goals of this project include:

- Quantifying the geochemical budgets for major and trace elements in the Bickford watershed and reservoir.

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\*planned funding

- Identifying the reactions and processes which control response of the watershed to acid deposition.
- Comparing the watershed study area with other regional watersheds.
- Developing predictive and ameliorative strategies to assist in mitigating possible long-term damage to surface water resources from acid deposition.

#### Project Description:

The project is a study of the fundamental processes which may be important in determining the response of a watershed and reservoir to continuing inputs of acid deposition. This will be carried out by employing the mass balance concept and focusing on biological buffering and alkalinity production processes in the watershed.

Specific tasks include:

- Conducting detailed hydrologic studies on the watershed.
- Compiling available data on water flow, water quality, and atmospheric deposition.
- Performing reservoir core analysis, including isotopic dating with  $^{210}\text{Pb}$ .
- Investigating the possible extent of sulfur and nitrogen transformations through charge balance considerations and preliminary geochemical mass balances.

#### Expected Output/Delivery Dates:

After completion of the currently funded 2 years in May 1983, a decision will be made regarding the possible continuation of this project.

Project Title:

Acid Rain/Fisheries Symposium (EE5)

Funding Organizations\*

American Fisheries Society  
American Fishing Tackle Manufacturers Association  
Association for the Protection of the Adirondacks  
National Lime Association  
Sport Fisheries Research Foundation  
Tenneco, Inc.  
Warner Company

Project Officer:

American Fisheries Society  
5410 Grosvenor Lane  
Bethesda, MD 20814  
(301) 897-8616

Research Organization and Principle Investigator:

Symposium Chairman

Terry A. Haines  
U.S. Fish and Wildlife Service  
c/o Zoology Department  
313 Murray Hall  
University of Maine  
Orono, ME 04469  
(207) 581-7151

Period of Performance:

August 1980 through July 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		-----(\$5,000)*-----			

\*Non-private sector funding was also provided by the U.S. Fish and Wildlife Service, the Canadian Department of Fisheries and Oceans, the U.S. Environmental Protection Agency, the Canadian Ministry of Natural Resources, the Canadian Embassy to the United States, and the Great Lakes Fishery Commission.

Research Objective:

The objective of this project was to convene a conference to:

- Review and summarize current knowledge concerning all aspects of the acid rain/fisheries problem.
- Explore the cause-effect relationships by which aquatic organisms are affected by acid rain.
- Consider the social and economic implications if remedial actions are not taken.
- Review the remedial actions available to protect fishery resources.

Project Description:

The conference was held during 2-5 August 1981 at Cornell University in Ithaca, New York, with approximately 360 individuals in attendance. Twenty five papers and 22 poster sessions were presented.

Output/Delivery Date:

The proceedings of this conference, entitled "Acid Rain/Fisheries: Proceedings of an International Symposium on Acid Rain and Fisheries Impacts in Northeastern North America," will be published in late 1982 by the American Fisheries Society.

Project Title:

Adirondack Land Use: A Commentary on Past and Present Impacts on  
Terrestrial and Aquatic Ecosystems (EE6)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will M. Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigators:

Paul F. Duhaime  
Walter C. Retzsch  
Everett and Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

October 1981 through April 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$10,000	

Research Objective:

The goal of this research was to evaluate the potential impact of various land use activities on terrestrial and aquatic ecosystems in the Adirondacks Mountains of New York state.

Project Description:

The project reviewed literature detailing past and present land use activities in the Adirondack Park area of New York State. The impact of past land use activities such as logging, forest fires, farming, mining, and recreation on the terrestrial and aquatic ecosystems of the region was detailed. Current land use activities and their potential influences on Adirondack forests, fisheries, and water quality were evaluated. Special attention was given to forest fire effects and to the potentially adverse impact on forest health due to present forest fire management programs in the

Adirondacks. All of the land use activities mentioned were evaluated for their potential contribution to natural acidification processes or their ability to mitigate the effects of acidification either from natural or anthropogenic sources.

Output/Delivery Date:

A report was submitted in May 1982.

Project Title:

Influence of Natural Acidity and Fisheries Management Activities  
Upon the Status of Adirondack Fish Populations (EE7)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202)457-7375

Research Organization and Principal Investigators:

A.G. Everett  
Walter C. Retzsch  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

November 1980 through May 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$16,100			

Research Objective:

The objective of this research was to examine scientific literature on factors other than acidic precipitation that may cause acidification of waters or reduce resident fish stocks.

Project Description:

Acidification is a natural process under certain conditions and precipitation acidified by industrial emissions appears to be only one of many possible causes of pond, lake, and stream acidification. Thus the "fishless" condition of some Adirondack waters may not be caused solely by "acid precipitation."

Literature and available data were reviewed pertaining to the following factors that may cause acidification or reductions of fish stocks:

- Intolerable environmental conditions resulting from:
  - Low pH environments created by natural conditions, such as peat bogs and coniferous forests.
  - Environments with elevated concentrations of toxic pollutants, such as pesticides and heavy metals.
  - Reduced oxygen concentrations with high CO<sub>2</sub> and H<sub>2</sub>S concentrations resulting from decaying organic matter.
  - Extreme temperatures.
  - Barriers to free transit created by natural or man-made dams.
  - Flow manipulations resulting from seasonal and weather conditions, drainage changes, and draw-down for flood control.
- Fisheries management and recreational fishing activities, such as:
  - Fish propagation and stocking practices.
  - Resource management activities.
  - Recreational fishing pressures.
- Changes in land-use activities.

Output/Delivery Date:

The final report was submitted to the U.S. Environmental Protection Agency (EPA) during May 1981 on behalf of API.



Project Title:

Natural Processes Contributing to the Acidification of Adirondack Waters (EE8)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Jimmie Nelson  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigator:

A. G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

September 1981 through May 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$140,000		

Research Objective:

The purpose of this field data collection and analysis program was to develop quantitative data on processes alternative to acid precipitation that may adversely affect water quality, specifically:

- Effects of natural acidification from certain wetland types.
- Chemical effects of the geological setting and of vegetation cover.
- Effects of insect control programs.
- Effects of changes in land use practices.

### Project Description:

The following areas were concentrated on:

- Natural acidification by certain wetlands. Interest in certain wetlands relates to their ability to increase the acidity of their environments by releasing hydrogen ions in exchange for cations and by other processes. This part of the field study concentrated upon water chemistry associated with specific wetland cover types. The field study collected water chemistry information used for initial estimates of the association between the presence of specific wetland cover types, their acidification status, and the acidification status of associated water bodies.
- Geochemical control of lake, pond, and stream chemistry. The geological settings of lakes, inflows, and outflow streams were determined by field reconnaissance and sampling, in order to determine the potential geochemical controls on runoff, soil water, and, where possible, base flow. The purpose of the geologic and soil setting study was to develop the geochemical characteristics of each watershed and to determine the pH and ion loading characteristics of runoff influent into wetlands, lakes, and streams. Available data on precipitation chemistry were used for comparison with runoff chemistry.
- Presence of residual pesticides. Past and present use of pesticides within the Adirondack region for control of biting insects presents the potential for adverse impacts upon aquatic invertebrates, non-target organisms, and fish species. To assess the existence of DDT and methoxychlor tied up with the fine, organic-rich fraction of the sediments, sediment cores and water samples from certain Adirondack lakes were collected and analyzed for levels of DDT and methoxychlor contamination. The results gave some indication as to the relative concentrations of DDT in the lake sediments and, if present, in the water column approximately 10 years after cessation of permitted DDT usage. Analysis of fine, organic-rich sediments, which are the most likely materials for retaining pesticides, further clarified whether past or current pesticide application programs are creating the possibility of long-term pesticide problems.

### Output/Delivery Date:

A draft report was produced in May 1982.

Project Title:

Pesticide Effects Upon Aquatic Biota in the Adirondack Region of  
New York State: An Alternative Explanation for Effects Attributed  
to Acid Precipitation (EE9)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will M. Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigators:

W.C. Retzsch  
A.G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

August 1980 through November 1980

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$16,600			

Research Objective:

The goal of this study was to examine the possibility that past and presently-used pesticides may cause detrimental effects upon fish populations in the Adirondack regions of New York state.

Project Description:

General pesticide literature and information pertaining to past and present Adirondack regional insect control programs was reviewed. The study revealed a variety of possible mechanisms and pathways by which pesticides may be presently exerting an adverse impact upon aquatic environments within the Adirondack region. The study reviews historical background, pesticide effects and toxicity, and persistence and residues. Subsequent field analyses are necessary

to verify the presence of persistent pesticides and to analyze potential accumulation pathways leading to chronic effects.

Output/Delivery Dates:

A final report was issued in November 1980.

Project Title:

Effects of Acid Precipitation on Smallmouth Bass (Micropterus dolomieu) (EE10)

Funding Organization:

Bass Research Foundation

Project Officer:

Tom Bankhead  
Scientific Coordinator  
Bass Research Foundation  
P.O. Box 99  
Starkville, MS 39759  
(601) 323-3131

Research Organization and Principal Investigator:

John E. Gannon  
Associate Director  
Research Center  
State University of New York  
Oswego, NY 13126  
(315) 341-3088

Period of Performance:

15 May 1980 through 15 September 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$5,238	\$10,477	\$5,238	

Research Objectives:

In many lakes in areas sensitive to acid precipitation, pH is often lowest in spring during the snowmelt runoff period. Therefore, spring spawners, such as smallmouth bass (Micropterus dolomieu), may likely be most exposed to low pH stress during their early life history stages. Consequently, a study was performed to ascertain the effects of acid stress on eggs, fry, and juvenile smallmouth bass under controlled laboratory conditions.

Project Descriptions:

Laboratory bioassays were conducted during 1980-81, behavior studies in 1981, and histopathology was examined in 1982:

- Laboratory Bioassays. Studies were directed at determining, under controlled laboratory conditions, the effect of various pH levels on the growth and survival of eggs, larvae, juveniles, and reproductive adults.
- Histopathological Studies. Work was aimed at identifying the developmental and morphological factors behind the changes in growth and survival observed in the bioassay work. This was accomplished by conducting exhaustive histopathological examination of eggs, larvae, juveniles, and reproductive adults exposed to the different experimental pH regimes.
- Behavioral Investigations. A series of experiments designed to identify subtle changes in behavior which could have significant effects on growth and survival, but which would not appear from histopathological analysis, were undertaken.

Output/Delivery Date:

Quarterly Progress Reports  
Final report, September 1982

Project Title:

A Feasibility Study to Utilize Liming as a Technique to Mitigate  
Surface Water Acidification (EE11)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Robert Brocksen  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2749

Research Organization and Principal Investigator:

Joe Wisniewski  
Manager, Acid Rain Studies  
General Research Corporation  
7655 Old Springhouse Road  
McLean, VA 22102  
(703) 893-5900

Period of Performance:

1 October 1980 through 31 December 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		-----\$96,269----			

Research Objective:

The object of this project was to evaluate the feasibility of  
liming as a technique for mitigating surface water acidification.

Project Description:

The application of calcium-based alkaline materials to lakes and  
other waterways was addressed. As part of this study, two staff  
members traveled to Scandinavia and Canada, where they interviewed  
researchers involved with liming operations and also participated  
in and/or observed the various liming techniques being employed.  
Specifically, the study addressed the following:

- The types and combinations of alkaline materials.
- Delivery modes.
- The input location.
- Application schedules.
- Cost-effectiveness.

An overview of the costs/benefits associated with several liming methods was undertaken, along with an assessment of potential chemical, physical, and biological changes resulting from short- or long-term lime applications. Finally, recommendations were suggested for research needed to more fully evaluate liming as a technique for mitigating the possible effects of acid deposition on water bodies.

Output/Delivery Date:

A final report entitled "Feasibility Study to Utilize Liming As a Technique to Mitigate Surface Water Acidification" was published as Electric Power Research Institute (EPRI) publication EA-2362 during June 1982.



Project Title:

Acid Precipitation Effects on Aquatic Processes: Methodology  
Development (EE12)

Funding Organizations:

Electric Power Research Institute (EPRI)

Project Officer:

Robert Kawaratani  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2969

Research Organization and Principal Investigator:

John Harte  
Lawrence Berkeley Laboratory  
Berkeley, CA 94720  
(415) 486-6119

Period of Performance:

18 August 1980 through 31 December 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		-----	\$502,492	-----	\$420,000**
			(\$150,748)*		(\$126,000)*,**

Research Objectives:

The purpose of this project is twofold:

- To further develop and improve the design of laboratory lake microcosms as a tool for assessing acid precipitation effects.
- To develop and evaluate a standard procedure for predicting the effects of acid precipitation and increased levels of toxic metals on decomposition processes in lakes.

\*funds related to acid deposition

\*\*planned funding

### Project Description:

Toward the first objective of this project, the following tasks were conducted:

- The effect of the rate of water-mixing on microcosm behavior was studied by measuring the dissolution of gypsum ( $\text{CaSO}_4$ ) at different depths and stations both within a lake and a dummy microcosm.
- The difference between active or passive water flow across the sediment surface was investigated. The effect of varying the amount of light reaching the sediment surface was also researched.
- Taxonomic comparisons between the lake and microcosms were conducted for both epilimnetic and hypolimnetic conditions (varying light, sediments, water, and water mixing rates).

With relation to the second objective, the following experiments are to be conducted by December 1983:

- Several different methods of measuring decomposition rates will be compared, including the  $\text{C}^{14}$  method.
- The relationship between the decomposition rates of detritus and measured ammonium ion ( $\text{NH}_4^+$ ) concentrations will be investigated.
- Sampling for two month periods in both late spring and mid-autumn will be undertaken in two study lakes at near shore and deep water stations to obtain background information about decomposition activity.
- An experiment will be undertaken to characterize problems, both short and long term, that may arise in proposed methods for determining effects of acid deposition and toxic metals.

### Expected Output/Delivery Dates:

A final report is planned for December 1983. Various journal articles will be prepared during the course of this project.

Project Title:

Acidic Deposition: Effects on Agricultural Crops (EE13)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

John Huckabee  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2589

Research Organization and Principal Investigator:

D.S. Shriner  
Environmental Sciences Division  
Oak Ridge National Laboratory  
Oak Ridge, TN 37830  
(615) 574-7356

Period of Performance:

1 January 1981 through 31 December 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$304,472	\$239,337	\$150,729*

Research Objective:

The objective of this research is to measure the effects of acid precipitation, in combination with gaseous pollutants, on economically important crops (specifically, soybeans) of the southeastern U.S. The effects to be studied are:

- Direct effects on crops during a growing season.
- Longer-term effects on productivity of soils.
- Degrees to which such effects are specific for a given crop, soil, and geographic site.

\*planned funding

### Project Description:

The effects of acid precipitation will be determined in relation to crop productivity in the field. Artificial rain of selected pH values will be substituted for normal rain. In addition to field studies, plants in closed chambers will have charcoal-filtered air supplemented with various levels of ozone ( $O_3$ ), sulfur dioxide ( $SO_2$ ), and/or nitrogen oxides ( $NO_x$ ). In all cases, there will be a number of different measurements of plant growth, including economically significant agronomic yield. Greenhouse studies will parallel the field studies to permit inferences concerning extrapolation of greenhouse findings to the field situation. Emphasis will be placed on:

- Characterizing plant response to stress from acid precipitation with and without gaseous pollutants.
- Simultaneous correlation of chemical and physiological indices.
- Analysis of a variety of soil characteristics relevant to agricultural productivity.

Four specific tasks will be undertaken:

- Task 1. Soil-Plant Response: Field. Growth and yield of field crops will be studied in relation to simulated acid precipitation with and without ambient gaseous pollutants.
- Task 2. Correlation of Indices. Field indices of crop physiological response will be correlated with concurrent chemical characteristics of pollutant stress.
- Task 3. Greenhouse Studies. The interaction of simulated acid precipitation and simulated gaseous pollutant episodes in the greenhouse will be studied.
- Task 4. Field Comparison. Open-field plots will be subjected to acid precipitation at two agriculturally different sites. The work will use a moisture-activated rainfall exclusion device.

### Expected Output/Delivery Date:

Final report, December 1983

Project Title:

Assimilation and Analysis of Data from Swedish, Canadian and  
Norwegian Limed Lakes (EE14)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Robert Kawaratani  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2969

Research Organization and Principal Investigator:

Joe Wisniewski  
Manager, Acid Rain Studies  
General Research Corporation  
7655 Old Springhouse Road  
McLean, VA 22102  
(703) 893-5900

Period of Performance:

1 February 1982 through 31 December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$80,000	

Research Objectives:

The objectives of this project were to:

- Assimilate data and create working computer files on Canadian, Norwegian, and Swedish limed lake data.
- Assess changes in pH, alkalinity, and other chemical parameters using data from seven of the Swedish lakes.

Project Description:

Data were obtained for: 34 limed Swedish lakes from the Swedish National Board of Fisheries; four Sudbury, Ontario area limed lakes from the Ontario Ministry of the Environment; one Nova Scotia lakes from the Department of Fisheries and Oceans, Environment Canada; and a single Norwegian lake from the Norwegian Institute of Water

Research. The data was received in raw printed form, manually written forms, or on computer tapes. Data includes the physical characteristics of the lake, along with information detailing the date of liming and amount of liming material added to each lake. Most of the data consist of chemical parameters measured in the lakes. The extent of the data varies widely between lakes, with some lake data sets limited to pH and alkalinity measurements and others containing measurements of up to 35 chemical parameters.

Initially, much effort was spent on creating consistent and compatible computer files for the data sets. Currently, several tasks are being performed to gain a better understanding of the changes in chemical parameters following the application of varying doses of lime into lakes with different physical characteristics. This effort has entailed assembling a series of scatter plots for each particular limed lake (e.g., pH versus various chemical parameters, pH versus alkalinity). In addition, correlation coefficients have been calculated for pH versus each of the chemical parameters. Further statistical analyses are to be performed.

Expected Output/Delivery Date:

Documentation of results will be completed by 31 December 1982.

Project Title:

Effects of Acid Deposition on the Nutrient Status of the Forest  
Ecosystem (EE15)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

John Huckabee  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2589

Research Organization and Principal Investigator:

Dale W. Johnson  
Environmental Sciences Division  
Oak Ridge National Laboratory  
P.O. Box X  
Oak Ridge, TN 37830  
(615) 574-7362

Period of Performance:

1 September 1980 through 1 September 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		-----\$260,000----		\$195,000	\$131,640*

Research Objectives:

The overall objective of this project is to evaluate the effect of atmospheric sulfur deposition on the nutrient status of soils and plants for three forest ecosystems in eastern Tennessee and two in western Washington. The following specific objectives have been identified:

- Determine the direct effects of  $H^+$  and  $SO_4^{2-}$  deposition on the nutrient status of five diverse forest sites, with the following sub-objectives:

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\*planned funding

- Determine the input of  $H^+$  in acid precipitation relative to the input of  $H^+$  by natural acid-forming processes in the soil.
  - Determine the fate of incoming sulfate ( $SO_4^{2-}$ ) and its effects on sulfur cycling and nutrient leaching from the ecosystem.
  - Determine potential sites for transformation of incoming  $SO_4^{2-}$  to gaseous forms.
- Determine the effects of  $H^+$  and  $SO_4^{2-}$  deposition on the decomposer invertebrate community in a deciduous forest ecosystem, and the consequences of this relative to phosphorus availability and cycling.

#### Project Description:

Toward the first objective, plots at the five forest sites are measured for the production of  $H^+$  from carbonic acid, nitrification, and the flux of  $SO_4^{2-}$  through the soil. Total sulfur and  $SO_4^{2-}$  flux via litterfall and  $H^+$  and  $SO_4^{2-}$  flux in incident precipitation and crownwash will be measured. Total nitrogen, total sulfur, and  $SO_4^{2-}$  content of study plot soils and vegetation at all sites will be determined to complete the organic and inorganic cycles and their relationships. Tension lysimeters will be installed and cation-anion balances will be determined for soil solutions. For the cycles of  $Ca^{2+}$ ,  $Mg^{2+}$ , and  $K^+$ , the range of values obtained from studies on nearby stands will be used.

Under anaerobic soil conditions,  $SO_4^{2-}$  may be transformed to gaseous form and lost by volatilization. On Walker Branch Watershed in Tennessee, there are a number of areas where drainage is poor due to low topographic relief and underlying compacted soil horizons which inhibit vertical drainage. Sulfur gas may be released to the atmosphere in these areas, especially during wet seasons. This flux will be measured using inverted chambers to trap the sulfur gas and an air pumping and sampling switching system connected to a sulfur gas analyzer. These measurements will be performed on control plots and fertilized plots in both nitrogen- rich and nitrogen-poor sites. If it is found that sulfur gas is released in measurable quantities, routine measurements will be taken with and without sulfur fertilization.

For the study of soil biota, 8m x 8m experimental plots will be established on Walker Branch Watershed. One of the treatments listed below will be assigned to each plot:

- Ambient levels of  $SO_4^{2-}$  and  $H^+$  (control).
- Double the annual mean  $SO_4^{2-}$  input ( $3.6 \text{ g/m}^2$ ).



- As  $\text{H}_2\text{SO}_4$ .
  - As neutral  $\text{SO}_4^{2-}$  salts.
- Ten times the annual mean  $\text{SO}_4^{2-}$  input ( $18 \text{ g/m}^2$ ).
- As  $\text{H}_2\text{SO}_4$ .
  - As neutral  $\text{SO}_4^{2-}$ .

Two methods of  $\text{SO}_4^{2-}$  application are included to provide a basis for separating the effects of sulfur (as sulfate) and those due to acidification. Both treatments will be applied as salts, one being a neutral salt and one being the acid form. Sampling for soil organisms will be done at monthly intervals, except earthworms, which will be sampled twice yearly.

Expected Outputs/Delivery Dates:

The expected end products of this research will be: 1) budgets of internal and acid precipitation input  $\text{H}^+$ ; and 2) organic and inorganic sulfur cycles (including sites and mechanisms of accumulation) in diverse forest ecosystems in the states of Tennessee and Washington.

Project Title:

Effects of Acid Precipitation on Agricultural Crops in the  
Northeast (EE16)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Research Organization and Principal Investigator:

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Period of Performance:

1 September 1980 through 15 August 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		-----\$168,220-----		\$148,740	\$71,150*

Research Objective:

The primary objective of this project is to assess the effects of acid precipitation on the yield of significant crops in the northeastern United States.

Project Description:

The work consists of two tasks:

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\* planned funding

- Task 1. Field Experiments. Crops of economic importance in the eastern U.S. will be grown in the field at Ithaca, New York, a region where ambient rain has pH values between 3.0 and 5.0. The variables to be tested will include:
  - Exclusion of ambient rain.
  - Exclusion of rain and addition of simulated rain containing concentrations of  $H^+$ ,  $SO_4^{2-}$  and  $NO_3^-$  within the ambient concentration ranges now occurring.
  - Exclusion of rain and addition of simulated rain and concentrations of  $SO_2$  at and below the current National Ambient Air Quality Standard (NAAQS) of 0.5 ppm for three hours.

Plants protected from rain will be irrigated to insure that there are no deficiencies in water supply from the soil. Ambient precipitation will be excluded by using a protective cover moved over the crop when signalled by a rain sensor. Simulated rain will contain  $SO_4^{2-}$  to  $NO_3^-$  mass ratios within the range found during rain events in the eastern U.S. Plants will be exposed to  $SO_2$  using either an open-air fumigation system or open-top chambers. All field trials will be performed with appropriate controls and statistical design. Several types of biological measurements will be performed. Estimates of growth and partitioning of photosynthate will be obtained using dry mass measurements of foliage, fruit, stem, and roots. Rates of development of the plant and crop will be recorded and estimates of yield will be made using dry mass measurements. Crop quality will be measured with assays of nutritive value and criteria of marketability.

- Task 2. Laboratory Experiments. Experiments will be performed in the laboratory from late fall through early spring each year in order to determine:
  - The life stage of the plant (seedling, vegetation growth, flowering) that is most susceptible to rain of differing composition.
  - The dose-response relationships for different concentrations and ratios of acidity,  $SO_4^{2-}$ ,  $NO_3^-$ , and  $SO_2$  concentrations within susceptible growth states.
  - The importance of factors such as frequency of events, duration of time between rain events, intensity of rainfall, fluctuation in acidity between and within events, day versus night exposures, and drying time of liquid on leaves.

These tests will be performed with crop plants grown in pots either in the greenhouse or in controlled-environment

chambers. Plants will be exposed, on a rotating turntable, to simulated rain at intensities and droplet diameters similar to those occurring in ambient rainfall. Data obtained from the National Atmospheric Deposition Program (see Project EM37) will be used to indicate the usual duration and frequency of rain events, as well as the concentrations of  $H^+$ ,  $SO_4^{2-}$ ,  $NO_3^-$  and other ions in the eastern U.S. Simulated rain solutions will contain concentrations of  $Cl^-$ ,  $Ca^{2+}$ , and  $NH_4^+$  in order to imitate the composition of ambient rain as closely as possible.

Expected Output/Delivery Date:

Final report, August 1983

Project Title:

Effects of Acid Precipitation on Agricultural Crops of the Midwest  
(EE17)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Electric Power Research Institute  
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Research Organization and Principal Investigator:

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Period of Performance:

15 May 1981 through 14 May 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$250,000	\$300,000	\$342,500*

Research Objectives:

The primary objective of this work is to perform controlled experiments designed to measure the current and potential impact of acid precipitation on the productivity of some major midwestern crop species (soybeans and winter wheat) utilizing realistic doses. A corollary objective is to ascertain the long-term effects of acid precipitation on typical midwestern agronomic soils, and to determine the potential for alteration of the productivity of these soils.

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\*planned funding

### Project Description:

To meet the before-mentioned objectives, the following tasks were assigned:

- Field Lysimeter Studies. To exclude ambient precipitation, the lysimeter complex will be covered by a weather-resistant shelter consisting of relatively transparent material supported by a heavy frame. Simulated rains at different pH values will be used with replicates of each crop/soil/rain pH combination. The chemical composition of the simulants will be based on the results of recent analyses of local rainfall at similar pHs. Additional lysimeters will also be installed outside the covered lysimeter complex, primarily for the purpose of monitoring soil change under ambient conditions. The same soil/crop combinations growing under the shelter will be used with replicates.

Plant samples will be periodically analyzed for the following constituents or parameters: (1) partitioning of photosynthate in above-ground portions of the plants; (2) soluble carbohydrate and starch content of various plant parts; (3) major and minor essential elements in plant parts; (4) chlorophyll; (5) cell death; (6) root biomass; (7) net photosynthesis and respiration, as well as stomatal diffusivity of leaves; and (8) the water relations of the plants in all lysimeters.

Also, at the conclusion of the growing season, yield parameters appropriate to the individual crop under study will be measured. The tissues, beans, or grain will be analyzed for protein, carbohydrates, oil, and mineral nutrients to determine the effects of the acid rain treatment on quality.

- Controlled Environment Studies (Plant Effects). Potted plants will be treated with the same quantities of the acid rain simulants used in the lysimeter studies. In addition, a second set of plants will be subjected to similar quantities of the rain simulants to either the foliage or soil alone. The combined effects caused by interactions of other environmental variables with the acid simulant treatments will be evaluated, particularly potential interactions with other atmospheric pollutants such as ozone ( $O_3$ ) and sulfur dioxide ( $SO_2$ ). The relation to variations in soil nutrient levels will also be investigated. Suitable and appropriate analyses will be selected corresponding to the constituents and parameters listed above under the first task.
- Controlled Environment Studies (Soil Effects). Greenhouse and laboratory studies will be performed with a variety of soil

types having a wide range of chemical and physical characteristics. Such studies will make it possible to apply the results of the relatively limited number of lysimeter experiments to a wider range of soil conditions in the modeling effort. The following observations and measurements will be made:

- Extensive soil characterization before and during the experiment.
- Changes in Eh and pH following precipitation events.
- Soil moisture tension.
- Soil temperature.
- Soil cations and anions in lysimeter leachate.
- Soil respiration (in situ) and soil enzymes (as a measure of microbial activity).
- Carbon turnover time of  $^{14}\text{C}$ -tagged litter.
- Soil carbohydrate and organic acid profiles.
- Water stable aggregates and soil dextranase activity.
- Nitrogen fixation, acetylene reductase activity, and Rhizobia numbers.
- Nitrogen flow as measured by observing mineralization rates.

Also, a Rhizobia selection experiment using Rhizobia meliolutia (the common symbiont of alfalfa) and R. trifolii (a less efficient and hence less desirable symbiont for alfalfa) will be performed in several of the lysimeters. R. meliolutia is known to be less resistant to increasing soil  $\text{H}^+$  activity than is R. trifolii; acid rain may therefore selectively eliminate R. meliolutia and thus cause reduced alfalfa yields by reducing nitrogen fixation.

- Environmental Measurements. The environmental conditions during the growing season at the lysimeter site will be characterized by continuous measurement of the following major environmental variables inside and outside the lysimeters: temperature, direct and diffuse radiation (total and photosynthetically active), relative humidity, wind speed and direction, rainfall, and ambient concentrations of common air pollutants, such as sulfur dioxide ( $\text{SO}_2$ ), ozone ( $\text{O}_3$ ), and nitrogen oxides ( $\text{NO}_x$ ).

Wet and dry (particulate) deposition will be collected separately using a HASL-style automatic collector in the vicinity of the uncovered lysimeters. Rain samples will be analyzed for pH, conductivity,  $\text{SO}_2$ ,  $\text{SO}_4^{2-}$ ,  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$  using ion chromatography, automated wet chemistry, atomic absorption spectrophotometry, and electrode techniques. Dry deposition will be analyzed for

sulfur and nitrogen species. In addition, wet samples will be titrated with base to determine total acidity.

Expected Output/Delivery Date:

Final report, 14 May 1984



Project Title:

Evaluation of Nitrogen Deposition on Forested Watersheds (EE18)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Research Organization and Principal Investigator:

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Period of Performance:

1 July 1981 through 10 July 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$37,000	\$197,475	\$292,800*
			(\$24,800)**	(\$132,308)**	(\$196,176)*,**

Research Objectives:

The project has the following objectives:

1. To quantify and compare nitrogen inputs via wet and dry deposition to three forested watersheds with potentially different loading rates and proximities to coal-fired power plants.

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\*planned funding

\*\*funds related to acid deposition

2. To quantify nitrogen loss via streamflow from the same three study sites and to compare and contrast atmospheric inputs and streamflow losses among the three study sites to evaluate the influence of nitrogen loading and nitrogen export.
3. To combine input and output data from this study with extant data on other aspects of the nitrogen status of the three study systems so that a mass balance incorporating inputs, outputs, and significant pathways and compartments can be developed for each watershed.

Project Description:

Methodology for Objective (1). Measurement of gaseous and particulate nitrogen inputs will be made using free-standing towers previously erected at each location. Sample intake points for nitrogen oxides ( $\text{NO}_x$ ) will be located five meters above the canopy, just below the canopy, and one meter above ground level. Information on wind speed, stability, and direction, along with temperature and humidity measurements, will also be collected on the tower. A continuous airflow system will be utilized to bring ambient air to a chemiluminescent  $\text{NO}_x$  monitor.

Inputs of particulate nitrogen will be measured three ways. First, polyethylene deposition plates will be positioned above, below, and within the canopy at two to three locations within each watershed. When collected, the plates will be washed with a standard volume of distilled water and passed through a nucleopore polycarbonate membrane filter. The wash water solution will be analyzed to determine the input of water soluble nitrogen while the particulate matter will be used to determine acid soluble inputs. The second approach will entail automatic continuous sampling through the use of a mini-Hivol system. Filters will be collected weekly and processed in a manner similar to the deposition plates. The third approach will utilize a HASL-type wet/dry collector to obtain discrete samples of wet and dry deposition. Two collectors will be located on top of the tower above the canopy. A second set of HASL collectors will be located at ground level beneath the canopy.

Samples for determining nitrogen input via precipitation will be collected on top of the tower above the canopy using the HASL type wet/dry collector. Samples will be collected on a weekly basis, and analyzed for Kjeldahl-N, nitrate ( $\text{NO}_3^-$ ), and ammonium ion ( $\text{NH}_4^+$ ) content. Throughfall samples will be collected from 20 locations within each watershed at the same time interval and composited for the month prior to nitrogen determinations. Throughfall samples will represent bulk precipitation modified by canopy interaction.

A special study will be initiated to examine changes in the nitrogen content of throughfall as it passes down through the canopy. Trough-like structures will be suspended at various levels within the canopy to quantify this change. The troughs will remain in an inverted position until a precipitation event is pending, in order to minimize dry deposition in the trough. The trough will then be placed in an upright position for the duration of the precipitation event. A sufficient number of events will be sampled in order to quantify possible trends in throughfall chemistry, as well as seasonal effects.

Stemflow samples will be collected weekly (composited by month) in circular plots with a radius of two meters. Every tree in the plot will be fitted with a water-tight collar designed to intercept water as it moves down the trunk of the tree. This approach will allow nitrogen inputs to the forest floor via stemflow to be expressed on a weight per unit area basis.

Methodology for Objective (2). Nitrogen export from the system will utilize standard flow determination procedures in conjunction with flow proportional sampling in order to quantify nitrogen flux in waters leaving the study areas. Automatic sampling equipment will collect samples of water on a flow proportional basis and be analyzed for Kjeldahl-N,  $\text{NO}_3^-$ , and  $\text{NH}_4^+$  content.

Methodology for Objectives (3). A first-order nitrogen mass balance will be developed for each study site, utilizing ongoing or previous work done by the Tennessee Valley Authority and Oak Ridge National Laboratory to supply data on nitrogen pools and transfers not addressed as a part of this work. Mass balance data from the proposed study sites (representing different geologies, hydrologies, soil types, and plant communities) will be compared to each other as well as to other mass balance studies such as Hubbard Brook and the Electric Power Research Institute (EPRI) Integrated Lake Watershed Acidification Study (see Project EE19) to further expand the predictive capabilities and the geographic base of the mass balance.

Expected Output/Delivery Date:

Final report, January 1984

Project Title:

Integrated Lake-Watershed Acidification Study (ILWAS) (EE19)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Research Organization and Principal Investigator:

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Period of Performance:

30 August 1977 through 30 June 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$1,057,800	\$1,200,000	\$1,300,000	\$701,380	

Research Objectives:

The following overall objective was formulated for this study:

- To quantitatively relate the deposition of atmospheric acid to the acidity of surface waters in the Adirondack Mountains of the United States.

The specific objectives of the program are summarized below:

- To measure the physical, chemical, and biological characteristics of the terrestrial and aquatic systems in three basins with varying degrees of lake acidity.
- To monitor the ambient air quality, specifically particulate forms of sulfate ( $\text{SO}_4^{2-}$ ) and nitrate ( $\text{NO}_3^-$ ) that may be deposited on the forest canopy during dry periods.

- To measure the quantity and quality of wet deposition that occur in the basins (undertaken as Project EM14).
- To measure the quantity and quality of the water at various points as it passes through the forest canopy, through the soil, and into the surface water system.
- To study the processes (e.g., throughfall chemistry modification, cation exchange between soil and infiltrating water) that occur as water passes through the various compartments of terrestrial and aquatic systems.
- To develop a mathematical model that will simulate the above processes and describe quantitatively how they interact in series and in parallel to produce the water quality observed at various points in the watersheds.

#### Project Description:

The research program divides the system into a series of compartments: basin input, basin hydrology, terrestrial systems, aquatic chemistry, and aquatic biology. The physical, chemical and behavioral characteristics of each compartment were measured in the field. The quantity and quality of water flowing into and out of each compartment was monitored. Data were used to test a mathematical model developed to simulate prototype hydrologic and biochemical processes. Using the characteristics of the three different basins as input, the model simulated quantity and quality of water at various points within each hydrologic system.

More specific descriptions of the major work areas are provided below:

- Basin Input. The following work, most of which was performed in Project EM14, was undertaken to characterize this compartment:
  - Meteorological monitoring.
  - Measurement of wet deposition.
  - Measurement of chemical characteristics of throughfall.
  - Ambient air quality monitoring.
  - Snow core quality determinations.
  - Investigation of litter deposition rates.
- Basin Hydrology. Field investigations of basin hydrology included:

- The running of snow cores.
- The measurement of surface water flow rates at different points on tributary streams.
- Lake inflow and outflow measurements.
- The measurement of groundwater potentials in unsaturated and saturated soil zones.
- Determination of interception losses and evaporation rates.

Results were used to develop hydrologic budgets from which the mass flux of dissolved constituents could be calculated.

- Terrestrial System. The following work was performed to research the terrestrial system component:
  - Vegetation survey.
  - Logging and fire histories.
  - Soil horizon investigations.
  - Physical and chemical properties of the soil horizons.
  - Soil horizon mineralogy.
  - Lysimeter measurements.
  - Aluminum investigations.
  - Microbially mediated decomposition.
  - Microbial adaption.
  - Indicator processes.
- Aquatic Chemistry and Biology. In the aquatic chemistry and biology programs, water quality was monitored at various points along the tributary streams and in the lakes proper. Additional water quality measurements were made in the bogs and at the bog inlets and outlets. Lake sediment profiles were dated and compared to the logging and fire histories of the basins. The presence/absence of acidophilic diatom frustules in the sediments was determined to indicate possible historical acidic episodes.

Specific items researched include:

- Water quality samples at lake inlets, outlets and for profiles in the lakes.
- Sediment profiles from each lake bottom.
- Mathematical Modeling. The project developed, calibrated, and verified a lake acidification process model. The model followed the fate (quantity and quality) of the precipitation from above the tree canopy, to, and through the soil system, and ultimately, to streams and lakes. The model included the integration of basin input, terrestrial system

characteristics, basin hydrology, and aquatic chemistry and biology. The integrated data were interpreted by two methods.

The first method entailed the use of a mathematical model to simulate lake acidification processes. This model accepts basin input data and simulates the hydrology and water quality at various points in the system (e.g., below the canopy, in the organic soil horizon, at the lake inlet(s), and at the lake outlet). Observed data were then compared with the model output. This model also is currently being verified and used to study the acidification process in several Wisconsin lakes (see Project EE25).

The second method entailed the calculation of the average flux of various ions and acidity along the pathways by which acid rain water becomes lake water. Based on the program design, basinwide flux of various ions was calculated above the canopy, below the canopy, through various soil horizons and stream segments, and into and through the lakes. Flux changes between any two physical points were explained by the environmental processes associated with the region between the two points.

Expected Output/Delivery Date:

Final report, December 1983

Project Title:

Materials Damage from Acid Deposition (EE20)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Research Organization and Principal Investigator:

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Period of Performance:

7 December 1981 through 7 December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$50,000	\$125,000	

Research Objective:

The objective of this research project is to derive the best estimates possible for materials damage from acid deposition and to suggest a research project to obtain improved estimates.

Project Description:

The project consists of the following studies:

- A review of the existing literature that relates acid deposition to materials damage.
- A retrospective study on the damage to materials exposed to acid deposition.



- An economic study of national and regional costs of materials damage due to acid deposition.

At the conclusion of this work, a study will be designed to provide more accurate measurement of air pollution exposure, coupled with continuous observation of the exposed materials.

Expected Output/Delivery Date:

A final report will be due in December 1982.

Project Title:

Microcosm Evaluation of Acidic Deposition on Forest Ecosystems  
(EE21)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Research Organization and Principal Investigator:

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Period of Performance:

1 July 1980 through 1 July 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		-----\$118,763-----		\$35,600	

Research Objectives:

The primary objective of this study was to provide needed insight into the integrated response of natural systems to altered precipitation chemistry. To address the problem of system response to acidic precipitation, a two-phase research program was formulated. Phase one was the development of a series of forest microcosms that would expose plants and soils to ambient environmental conditions, while excluding naturally occurring precipitation. Phase two of the research program utilized a range of precipitation pH treatments to evaluate system function in terms of indices which have direct bearing on plant productivity and soil fertility. To achieve this end, four specific objectives were formulated:

1. Determination of foliar leaching rates and plant nutrient content.
2. Determination of leaf physiological and morphological responses.
3. Determination of decomposition rates in litter and mineral soil.
4. Determination of leaching rates of soil nutrients.

Project Description:

The specific tasks of the four objectives were as follows:

- Task 1. Changes in nutrient content of three tree species in each microcosm were examined from analysis of leaf tissue and throughfall samples. Leaf tissue samples were collected prior to treatment initiation and at the end of each subsequent growing season. Leaf tissue was analyzed for  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{PO}_4^{3-}$ , sulfur, and nitrogen content. Throughfall was collected during each period of treatment at four locations within each microcosm.
- Task 2. The dates of leaf emergence, development of senescence, and the progress of leaf fall were recorded along with monthly measurements of diameter growth. The occurrence and extent of visible injury was determined by treatment, leaf position, and stage of leaf development. Leaf area and needle length determinations were utilized to quantify injury on an area basis. Stomatal function of the broad-leaved species was measured on representative leaves with a Li-Cor diffusion resistance parameter. Estimates of stomatal frequency and size were made microscopically from silicone impressions taken after completion of leaf expansion. These estimates were used to relate visible injury with stomatal density and to assist in the selection of uniform tissue for subsequent measurements of photosynthesis and respiration. Finally, after the completion of the gas exchange measurement, the following parameters were analyzed: leaf thickness, cuticle thickness, changes in tissue morphology, chlorophyll a, chlorophyll b, and total chlorophyll.
- Task 3. In situ carbon dioxide ( $\text{CO}_2$ ) efflux--the inverted box method--was used to trap  $\text{CO}_2$  released from the microcosm floor. Carbon dioxide efflux was determined biweekly and the traps were left in place for 24 hours to take into account diurnal variations in  $\text{CO}_2$  release. Respiration rates of forest floor soil components were measured quarterly from

hand-separated samples of the 01 litter, 02 litter, and the major soil horizons. Subsamples of each of these components were monitored for  $O_2$  uptake and  $CO_2$  efflux manometrically using a Gilson differential respirometer. Following the determination of  $CO_2$  evaluation rates, litter and mineral soil samples were analyzed for  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$ ,  $K^+$ ,  $PO_4^{3-}$ , sulfur, nitrogen, and pH.

- Task 4. Nutrient flux in the soil solution was determined on a monthly basis, with soil leachate collected, when possible, after each precipitation event and composited into one sample for the month. Samples were collected at depths of 25, 50, and 100 cm and analyzed for pH, conductivity, total-N,  $NH_4^+$ ,  $NO_3^-$ ,  $SO_4^{2-}$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $PO_4^{3-}$ ,  $K^+$ ,  $Na^+$ , and  $Cl^-$  content. Estimates of element flux from the system were obtained from the 100 cm samples, while the 25 and 50 cm samples provided information on changes in leachate chemistry as water passed through the soil profile. These data provided considerable insight into the impact of varying levels of acidic deposition on soil solution chemistry.

Output/Delivery Date:

Final report, September 1982

Project Title:

Regional Integrated Lake-Watershed Acidification Study (RILWAS)  
(EE22)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Research Organization and Principal Investigator:

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Period of Performance:

1 April 1982 through 31 December 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$526,000	\$1,525,289*

Research Objective:

The objective of this project is to develop a methodology to assess on a regional basis the effects of acidic deposition on lake acidification.

Project Description:

The work will include four major tasks:

- Task 1. Twenty lake basins in the Adirondacks will be selected to test the applicability of knowledge gained from the Integrated Lake-Watershed Acidification Study (ILWAS)

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\*planned funding

study (see Project EE19), with the following subtasks implemented:

- Twenty lake basins in the Adirondacks will be selected.
  - Regional estimates of wet and dry deposition will be made.
  - Basin forest canopy, geology, and mineralogy will be characterized, based on existing maps supplemented by additional survey data.
  - Historical hydrologic records from existing gauging stations in the Adirondack region will be examined. Hydrologic characteristics of Adirondack basins will be described, with special emphasis on factors which allow separation of the hydrograph components (i.e., surface runoff, interflow, and ground water flow) and on the base to total flow ratios. Geographic distribution of hydrographic characteristics will be compared to the geographic distribution of acid lakes.
  - Monthly measurements of lake stage will be made at the 20 lakes, with extra stage readings made during the snowmelt period. Flow measurements at the control sections of the lake outlets will be made four times a year to establish stage/flow relationships.
  - Lake water quality will be characterized by monthly profiling and monthly lake outlet sampling. Additional samples at lake outlets will be taken during snowmelt periods.
  - Surveys will be made of fish population composition, as well as the adequacy of fish spawning grounds and nursery areas for each of the 20 lake basins selected. Observations of spawning activity at the spawning grounds and the presence of young fish in the nursery areas will be made at appropriate times.
  - The ILWAS model will be applied and tested on one lake representative of each of the typical groupings of lake basins.
- Task 2. Because of the large number of Adirondack lakes it would be too costly and time consuming to apply the ILWAS model to each individual lake-watershed for projection. Therefore, a classification system will be developed for lake basins, with the model applied individually to lake basins representative of the characteristic groupings. Likely lake and watershed responses to increases or decreases in acid deposition will be developed for the representative lakes. Effort will be concentrated on some 300 medium to low alkalinity lakes, with the following subtasks undertaken:
- For each characteristic grouping of lake basins, sensitivity analyses will be made with the ILWAS model to

develop relationships for response (i.e., magnitude and time) versus basin characteristics (e.g., canopy, successional stage, soil horizon thickness, hydraulic conductivity, basin sizes, and lake surface to basin areas).

- For each characteristic grouping of lake basins, the ILWAS model will be used to develop and quantify relationships for response (e.g., surface water pH and total aqueous  $\text{Al}^{3+}$  concentrations) to changes in the acidity of deposition.
- Using model output, a series of curves (e.g., alkalinity supply rate versus external acid loading rate) will be developed to facilitate projection of lake response to future increases or decreases in acid deposition.
- Based on existing data, Adirondack lakes will be classified into the established characteristic groupings of lake basins. Projections will then be made for lake response with respect to increased or decreased acid deposition.

- Task 3. The following subtasks will be implemented, in order to: (1) advance the knowledge of lake-watershed acidification phenomena; (2) fill knowledge gaps as necessary for the projection of response; and (3) test the validity of ILWAS model predictions:

- Field verification of flow paths through soil horizons and surface flow as predicted by the ILWAS model in two basins.
- For the major weatherable minerals, determination of weathering sequences (A-B-C), weathering rates, and the dependency of the weathering rates on pH, partial pressure of  $\text{CO}_2$ , and grain size.
- Determination of plant nutrient uptake and its impact on alkalinity production in soil solution in the root zone.
- The role of the base to total flow ratios, and the results of hydrographic recession analysis as predictors of flowpaths (surface, interflow, and groundwater) and the sensitivity of a lake to acidification.
- The role of hydraulic conductivity and in particular the hydraulic conductivity of the widespread aeolean mantle in determining flowpaths.
- The role of precipitation quantity as a predictor of atmospheric acid loading.
- The role of  $\text{F}^-$  in the mobilization of  $\text{Al}^{3+}$ .
- The role of lake water pH,  $\text{Al}^{3+}$  concentration, temperature, spawning grounds, nursery areas, and fish planting programs in determining whether a lake will or will not support fish life.

- Task 4. The ILWAS model will be applied to two lakes in Wisconsin (see Project EE25), with the following subtasks performed:
  - Modification of the model to accommodate seepage lakes where there is no surface outflow.
  - Calibration and verification of the model with Wisconsin data.
  - Projection of acidification state under various conditions of acid deposition.

Expected Output/Delivery Date:

Final report, December 1985



Project Title:

Relationships of Acid Deposition, Lake Acidification, and Fish  
(EE23)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Robert Brocksen  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2749

Research Organization and Principal Investigator:

Michael Marcus  
Western Aquatics, Inc.  
209 Grand Avenue  
Laramie, WY 82070  
(307) 742-7624

Period of Performance:

3 August 1981 through 28 February 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$47,566	\$15,822	

Research Objectives:

The objectives of this project were to evaluate the current state of knowledge regarding the relationships among acid deposition, lake acidification, and fish, as well as to identify those North American fish populations and communities most vulnerable to surface water acidification.

Project Description:

By reviewing the scientific literature, directly contacting investigators, and attending the Acid Rain/Fisheries Symposium (see Project EE5), the following work was completed:

- The current scientific positions regarding the relationships among acidifying atmospheric deposition, decreases in surface

water pH, and responses of fish populations and communities were reviewed.

- Data bases through which these positions were derived were evaluated and the extent to which other available data support these positions was determined.
- Documented cases of surface water acidification leading to declines in fish populations were identified, as well as sources of acidification when possible.
- The relative effects on fish populations and communities due to decrease in pH alone, and in combination with heavy metals and other toxic chemicals, were evaluated.
- Future research efforts that may be beneficial in clarifying these relationships were suggested.

Expected Output/Delivery Date:

A published Electric Power Research Institute (EPRI) report is expected by the end of 1982.

Project Title:

The Effects of Sulfur Dioxide (SO<sub>2</sub>) and Ozone (O<sub>3</sub>) on Selected Agricultural Crops (EE24)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Ronald E. Wyzga  
Energy Analysis and Environment Division  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2577

Research Organization and Principal Investigator:

Joe Wisniewski  
Manager, Acid Rain Studies  
General Research Corporation  
7655 Old Springhouse Road  
McLean, VA 22102  
(703) 893-5900

Period of Performance:

1 July 1980 through 31 December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$131,000	\$140,000	\$15,000	
		(\$19,650)*	(\$10,000)*		

Research Objective:

The objective of this work was to assess the effects of several air pollutants on selected agricultural crops.

Project Description:

In this study, an assessment was made of the effects of SO<sub>2</sub>, O<sub>3</sub>, NO<sub>x</sub>, and acid precipitation on selected agricultural crops. A workshop was conducted at Corvallis, Oregon, to determine the best approach for the use of experimental dose-response data in an

\*funds related to acid deposition

economic assessment. Following the workshop, it was decided to limit the assessment to the effects of SO<sub>2</sub> and O<sub>3</sub> on several agricultural crops, due to a lack of reliable experimental data. For the final document, only a literature review was performed regarding NO<sub>x</sub> and acid deposition effects on forest and agricultural species.

A Delphi survey technique was performed to enlist the aid of experts on specific questions related to the effects of air pollutants on crops. The experts helped select the most appropriate functions representing response of crops to SO<sub>2</sub> or O<sub>3</sub> exposures. Detailed analyses were performed on important crops in four Air Quality Control Regions (AQCRs), as well as analyses at the state, regional, and national levels. These analyses involved combining 1978 crop yield data obtained from the Census of Agriculture with 1978 air quality data obtained from the EPA Storage and Retrieval of Aerometric Data (SAROAD) system, using dose-response algorithms to estimate crop losses.

Output/Delivery Date:

A draft final report was submitted in February 1982.

Project Title:

Wisconsin Acid Deposition Cooperative Research Program  
Watershed Research Program (EE25)

Funding Organizations: \*\*\*

Electric Power Research Institute (EPRI)  
Wisconsin Utilities Association

Project Officer:

Thomas Wirth  
Wisconsin Department of Natural Resources  
3911 Fish Hatchery Road  
Madison, WI 53711  
(608) 266-3237

Principal Investigator:

same as Project Officer

Period of Performance:

1 August 1981 through June 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$178,400	\$334,122	(\$308,446)**
			(\$106,000)*	(189,322)*	(\$163,646)*,**

Research Objectives:

The Wisconsin Acid Deposition Cooperative Research Program includes four study programs (each program is described as a separate project in this document - consult the Funding Organization Index), with the following overall objectives:

- To identify sources and levels of acid deposition in Wisconsin.
- To quantify susceptible resources and the possible environmental effects of acid deposition.

\*funds supplied by the private sector organizations

\*\*planned funds

\*\*\*Funding also supplied by the Wisconsin Department of Natural Resources and the U.S. Geological Survey.

- To identify and quantify the potential of current control and mitigatory technologies for reducing the potentially adverse effects of acid deposition.

Detailed specific research objectives of the Watershed Research Program are as follows:

- To determine the quantity and quality of atmospheric deposition in two northern Wisconsin watersheds.
- To assess the modification of precipitation by various forest cover types, and describe the modification of the water as it passes through the soils.
- To determine the hydrologic budgets and assess the impact of budget components on lake-water quality.
- To investigate the impact of acid deposition on lake biota.
- To evaluate the pathological effects of acid precipitation on the foliage of vegetation.
- To integrate the research findings by two models, i.e., elementary flux calculations and mathematical modeling.
- To adapt, calibrate, and verify the ILWAS model (see Project EE19) to the two watersheds.

#### Project Description:

For the final selection of study lake watersheds, an extensive screening process was employed, considering many factors (e.g., no stream inlets, apparent high or medium susceptibility to acid deposition, fish populations typical of the region). The project consists of studying the selected watersheds in four segments:

- Atmospheric Input.
- Terrestrial System.
- Basin Hydrology.
- Limnology.

Atmospheric input is being measured in the Deposition Monitoring Network (see Project EM42), in addition to samples being collected by the researchers from the terrestrial system and the basin hydrology components at the lakes themselves. A station has been established at Round Lake for the measurement of wet and dry deposition. Deposition is collected on the event basis in an Aerochem Metrics Model 301 automatic sensing wet and dry collector. In addition, bulk deposition is collected in three collectors at both lake sites at approximately biweekly

intervals. Throughfall and stem flow volumes and their chemistry are investigated for three typical canopy types.

Basin characteristics will be determined for each watershed, including:

- Vegetation.
- Biomass, net primary productivity, and nutrient capital.
- Soil inventory and nutrient capital.
- Soil mineralogy.
- Topography.

The following vegetation dynamics also are monitored: leaf area index, litterfall, litter decomposition, and canopy pathology. Soil parameters such as chemical composition in the O, A and B horizons, as well as soil moisture and temperature, will be studied.

The following watershed hydrological parameters are monitored:

- Lake bathymetry.
- Surface flow.
- Groundwater flow.
- Lake surface elevation.
- Snow quality and depth.
- Hydraulic conductivity.
- Lake sediment permeability.
- Evaporation.

Lake water quality is assessed every two weeks from May through September, and once a month during the rest of the year. Groundwater quality is also monitored monthly. Lake biology is sampled, including fish, phytoplankton and zooplankton, macrophytes, and benthos.

Solutions collected as wet deposition throughfall, stemflow, soil leachate, groundwater, and lake water will be analyzed for the following chemical constituents:

pH, conductivity, total acidity, alkalinity,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{NH}_4^+$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{Cl}^-$ ,  $\text{Al}^{3+}$ , Fe, Mn, and  $\text{SiO}_2$ .

Soil samples and tissue samples will be analyzed for the following elements:

S, N, P,  $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$ , Fe, Mn, and Zn.

Data analysis will include calculations of hydrological and chemical budgets:

- Hydrologic Budget. A monthly hydrologic budget will be prepared for each lake. Based on these budgets, the relative contributions of surface flow, precipitation, evaporation, and seepage into and from the lakes will be determined.
- Chemical Budget. A mass balance approach will be used to show monthly chemical fluxes through the forest canopy, the soil system, and the lake. Examination of chemical fluxes between the various components of the lake watershed will provide for integrated interpretation of the data.

Finally, the Electric Power Research Institute and Tetra Tech, Inc. are developing a lake-watershed acidification model that attempts to simulate the hydrologic and biogeochemical processes occurring in watersheds and in lakes (see Project EE19). The model is being developed and tested with data collected in the Adirondack region of New York, and will be applied in this study. Application of the model to Wisconsin watersheds requires the following steps:

- Modification of the model to accommodate seepage lakes situated in glacial drift outwash that may be 100 meters or more thick.
- Supply of site-specific basin characteristics for model input.
- Calibration and verification of the model with the new data collected.
- Characterization of acidification state under various levels of acidic deposition.

EPRI has contracted Tetra Tech, Inc. (see Project EE22) to accomplish the four steps listed above, while the model will be run by the Department of Natural Resources, the University of Wisconsin, and the U.S. Geological Society.

Expected Output/Delivery Date:

The final report will be produced by June 1984.



Project Title:

Florida Acid Deposition Study  
Ecological & Material Effects Program (Program 3 of 4) (EE26)

Funding Organization:

Florida Electric Power Coordinating Group, Inc.  
402 Reo Street, Suite 214  
Tampa, FL 33609  
(813) 877-5301

Project Officer:

Charles D. Henderson  
Environmental Affairs Department  
Florida Power & Light Company  
P.O. Box 529100  
Miami, FL 33152  
(305) 552-4819

Research Organization and Principal Investigator:

E.R. Hendrickson  
Project Director  
Environmental Science & Engineering, Inc.  
P.O. Box ESE  
Gainesville, FL 32602  
(904) 372-3318

Period of Performance:

January 1981 through March 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$70,000	\$55,000	\$135,000*

Research Objectives:

The Florida Acid Deposition Study's primary objective is to assess and develop information needed to place the acid deposition issue in proper perspective for Florida as to its magnitude, variability, sources, effects, and control options. The study is divided into four study programs (each program is described as a separate project in this document - consult the Funding Organization Index)

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\*planned funding

and four time phases, to allow periodic reassessment of the desirability of continuing funding or changing direction.

The specific objectives of the Ecological & Material Effects Program are:

- To evaluate the potential effects of acid deposition on lakes and streams.
- To determine the potential susceptibility to acid deposition of agricultural, commercial, and other important vegetation of Florida, including citrus, sugar cane, pines, cypress, potatoes, cabbage, and tomatoes.
- To determine the potential effects of acid deposition on man-made materials such as buildings, coverings, etc.

Project Description:

During Phase I (January through September 1981), the approach was to collect and critique relevant literature and other information sources regarding possible impacts on ecological and man-made materials due to acid deposition in Florida. Completed studies and ongoing research by the Electric Power Research Institute (EPRI), the U.S. Environmental Protection Agency (EPA), the Tennessee Valley Authority (TVA), the Oak Ridge National Laboratory, the University of Florida, and other groups were reviewed. Work performed in the National Crop Loss Assessment Network (NCLAN) of EPA and studies by the Utilities Air Regulatory Group (UARG) were assessed. The program at EPRI, which includes examination of the effect of acid deposition on a variety of soils, will be followed closely. Through this literature review, gaps where insufficient information exists to draw conclusions were identified.

Experimental techniques employed and their applicability to the Florida environment were evaluated. Florida-specific studies were recommended if necessary to meet the main purposes of the study. Based on existing information regarding the structure and function of Florida's lakes, the feasibility of developing a survey of the susceptibility of representative lakes to the potential effects of acid deposition was determined.

During Phase II (October 1981 through September 1982), experiments were proposed to address areas where additional research is needed.

Expected Outputs/Delivery Dates:

As previously state, this project consists of four phases. Phase I started in January 1981 and ended in September 1981, with a interim

report published in January 1982. Subsequent phases (as currently planned) are as follows:

Phase II	October 1981 - September 1982
Phase III	October 1982 - September 1983
Phase IV	October 1983 - March 1985

Interim reports will be produced after completion of each phase, with a final report expected in mid-1985.

Project Title:

Acid Rain and the Atlantic Salmon Conference (EE27)

Funding Organizations\*:

International Atlantic Salmon Foundation  
Sport Fishing Research Foundation  
Trout Unlimited

Project Officer:

Andrew Stout  
International Atlantic Salmon Foundation  
P.O. Box 651  
Hanover, NH 03755  
(603) 643-6525

Research Organization and Principal Investigator:

not applicable

Period of Performance:

July 1979 through March 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	-----	\$5,000-----			

Research Objective:

The purpose of this project was to convene a conference to address the possible impacts of acid precipitation on the Atlantic salmon.

Project Description:

The conference was held during 22-23 November 1980 in Portland, Maine. Approximately 350 international conservationists, scientists, and politicians were in attendance, with 24 papers delivered.

Output/Delivery Date:

The 174 page proceedings, entitled "Acid Rain and the Atlantic Salmon," were published in May 1981 as International Atlantic Salmon Foundation Special Publication 10.

\*non-private sector funding also supplied by the Natural Resources Council of Maine

Project Title:

An Assessment of the State of Knowledge on the Effects of Acidic Deposition on Forest Ecosystems (EE28)

Funding Organization:

National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI)

Project Officer:

Russell O. Blosser  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9001

Research Organization and Principal Investigator:

John E. Pinkerton  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9047

Period of Performance:

1 April 1980 through 31 March 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$5,000	\$5,000		

Research Objective:

The objective of this project was to assess the status of current knowledge regarding the effects of acidic deposition on the forest ecosystem.

Project Description:

As the result of a literature review, the effects of acidic deposition on forest ecosystems were characterized. Ongoing and planned research projects on the topic were identified from contacts with university, government, and private industry scientists. Information needs facing the forest products industry were summarized.

Output/Delivery Date:

A report entitled, "Acidic Deposition and Its Effects on Forest Productivity - A Review of the Present State of Knowledge, Research Activities, and Information Needs," was published in January 1981 as NCASI Atmospheric Quality Improvement Technical Bulletin No. 110.

Project Title:

Assessment of Methods for Identifying Changes in the Chemical Characteristics and Nutrient Status of Forest Soils Affecting Timber Growing Productivity Which Might Be Related to Acidic Deposition (EE29)

Funding Organization:

National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI)

Project Officer:

Russell Q. Blosser  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9001

Research Organization and Principal Investigator:

John E. Pinkerton  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9047

Period of Performance:

1 October 1981 through 31 March 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$5,000	Dependent on initial findings

Research Objective:

The goal of this project is to identify acid deposition-related changes in forest soils which might affect timber productivity.

Project Description:

Initial efforts will be directed towards identifying forest soil physical and chemical parameters which would indicate soil sensitivity to acidic deposition inputs. Selection of the most appropriate sampling and measurement techniques for the identified parameters will follow. Finally, measurements on selected control and growth plots will be conducted in a number of areas with

various forest soil types to determine what effects relatable to timber growing productivity, if any, acidic deposition is having on different forest soils.

Expected Output/Delivery Date:

A report on parameter identification and measurement techniques is due in December 1982.



Project Title:

Acid Rain Vulnerability of the 27 States East of the Mississippi River (EE30)

Funding Organization:

National Wildlife Federation

Project Officer:

Kenneth S. Kamlet  
Director, Pollution and Toxic Substances Division  
National Wildlife Federation  
1412 16th Street, N.W.  
Washington, D.C. 20036  
(202) 797-2945

Research Organization and Principal Investigator:

Gail Einbender  
National Wildlife Federation  
1412 16th Street, N.W.  
Washington, D.C. 20036  
(202) 797-2947

Period of Performance:

August 1981 through October 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$1,667	\$3,333		

Research Objective:

The research objective was to assess the overall acid rain vulnerability of the 27 states east of the Mississippi River, based on the sensitivity of their resources and precipitation acidity.

Project Description:

Data from published acid rain studies, precipitation chemistry monitoring stations, and personal communication with scientists were used to rank the 27 states according to their vulnerability to fishery, soil, crop foliage, and masonry damage. Measurements of existing visibility impairment and automobile paint damage were also considered. A relative ranking of the state vulnerabilities was based on the sum of their acid precipitation sensitivities.

Output/Delivery Date:

A final report was published in October 1981.

Project Title:

NSP/Sherburne County Generating Plant Terrestrial Vegetation Study  
(EE31)

Funding Organization:

Northern States Power Company

Project Officer:

G. David Heberling  
Northern States Power Company  
414 Nicollet Mall  
Minneapolis, MN 55401  
(612) 261-4100

Research Organization and Principal Investigator:

Sagar V. Krupa  
University of Minnesota  
Department of Plant Pathology  
1519 Gortner Avenue  
St. Paul, MN 55108  
(612) 376-3871

Period of Performance:

1 April 1976 through 1 April 1986

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$136,000	\$59,000	\$59,000	\$60,000**	\$247,000***
	(\$60,000)*	(\$31,000)*	(\$31,000)*	(\$33,000)*,**	(\$125,000)*,***

Research Objective:

The primary objective of this study is to investigate the possible impact of the Sherburne County Generating Plant on terrestrial vegetation and soils within a 50 mile radius of the source.

Project Description:

Air pollution-visible injury surveys are conducted on cultivated and native vegetation in a 50 mile radius from the Sherburne County

\*funding related to acid deposition

\*\*estimated funding

\*\*\*proposed funding

Generating Plant during June through September of each year. Attention is focused upon both acute and chronic plant injury, which are assessed from visual examination and documented by written description and photography. Information gathered in this exercise is coordinated with data from several acid deposition studies conducted in the area.

Soil and vegetation in roughly 48 field plots are sampled during June and August of every year and analyzed for elemental composition. Soil samples are divided into 0-6 inch and 6-12 inch samples. Total sulfur is measured using plant tissue digestion and optical methods. Trace metals are analyzed by digestion and inductively coupled plasma spectrometry.

Detailed parametric and/or non-parametric numerical analyses of the chemical analyses data will be performed toward explaining any possible effects of the source emissions on terrestrial vegetation and soils.

Expected Output/Delivery Dates:

A detailed report summarizing the previous year's research activities is submitted to Northern States Power Company by 1 April of each year.

Project Title:

A Biological and Chemical Survey of Vulnerable Pocono Mountain  
Lakes to Determine the Biological and Chemical Impact of Acid  
Precipitation (EE32)

Funding Organization:

Pennsylvania Power and Light Company

Project Officer:

Heinz G. Pfeiffer  
Manager, Technology and Assessment  
Pennsylvania Power and Light Company  
2 North Ninth Street  
Allentown, PA 18101  
(215) 821-5884

Research Organization and Principal Investigator:

Patricia T. Bradt  
Adjunct Associate Professor  
Department of Biology  
Williams Hall #31  
Lehigh University  
Bethlehem, PA 18015  
(215) 861-3691

Period of Performance:

1 September 1980 through 31 December 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$35,595	\$54,417	\$50,000*

Research Objectives:

The project has the following research objectives:

- To identify lakes in the Pocono Mountains area of eastern Pennsylvania which may be vulnerable to damage from acid precipitation.

\*proposed funding

- To examine closely the biology and water chemistry of three high risk lakes to determine if there has been any impact from acid precipitation.
- To provide a data base for use in future studies and to evaluate historical data.
- To determine if there is any evidence that the biota and/or chemistry of high risk Pocono Lakes is being influenced by acid precipitation.

Project Description:

The following tasks will be performed during the indicated years:

- 1980
  - chemical survey of 11 Pocono Lakes
- 1981
  - gather historical data
  - chemical survey of 11 Pocono Lakes considered at high risk (spring)
  - choose three lakes to study intensively for 3 years
  - biological and chemical survey of three high risk lakes (summer and fall)
- 1982
  - laboratory chemical and biological analyses of summer and fall 1981 samples
  - continue search for historical data
  - biological and chemical sampling of three high risk lakes (spring, summer, and fall)
- 1983
  - laboratory chemical and biological analyses
  - biological and chemical sampling of three lakes (spring and summer)
  - analyze results
  - report generation

Expected Output/Delivery Dates:

Semi-annual reports will be provided to Pennsylvania Power and Light Company, with the final report due in December 1983.

Project Title:

The Potential for Acidification of Soils, Water Bodies, and  
Agricultural Lands in San Diego County (EE33)

Funding Organization:

San Diego Gas & Electric Company

Project Officer:

L. Jack Brunton  
Supervisor, Environmental Regulation  
San Diego Gas & Electric Company  
P.O. Box 1831  
San Diego, CA 92112  
(714) 232-4252

Research Organization and Principal Investigator:

John Larson  
RECON  
1094 Cudahy Place, Suite 204  
San Diego, CA 92110  
(714) 275-3732

Period of Performance:

October 1981 through July 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$15,000	

Research Objective:

The goal of this research was to assess the potential  
susceptibility of San Diego county soils and large water bodies to  
acid rainfall.

Project Description:

Literature research was undertaken to identify the location and  
physical characteristics of San Diego county soils and large water  
bodies. Land use activities were also researched. An assessment  
of the potential of acid precipitation to alter soil acidity was  
conducted considering soil base saturation, soil cation exchange  
capacity, present acid precipitation inputs, and acid precipitation  
inputs 10 times the current levels. Similarly, the potential for  
alteration of large water body acidity was investigated,

considering water body alkalinity, present acid precipitation inputs, and acid precipitation inputs 10 times the current levels.

Expected Output/Deliver Date:

A final report, entitled "The Potential for Acidification of Soils, Water Bodies, and Agricultural Lands in San Diego County," will be completed by late 1982.

Project Title:

Effects of Acid Deposition on Terrestrial and Aquatic Ecosystems in  
the Southwestern United States (EE34)

Funding Organization:

Southern California Edison Company

Project Officer:

Carl A. Fox  
Southern California Edison  
P.O. Box 800  
Rosemead, CA 91770  
(213) 572-1212

Research Organization and Principal Investigator:

A. L. Page, Director  
Program of Excellence in Environmental Research  
University of California  
Riverside, CA 92501  
(714) 787-3654

Period of Performance:

July 1980 through 31 December 1988

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		not available			

Research Objective:

The aim of this study is to assess various aspects of the direct and indirect effects of acid deposition on soils, vegetation, and aquatic systems.

Project Description:

Research has been undertaken in the following areas:

- Lake monitoring.
- Assessing natural sources of acidity.
- Assessment of soil sensitivity to acid precipitation.
- A watershed mass balance study.



One hundred and twenty-four lakes in the Sierra Nevada Mountains have been monitored for pH, conductivity, and major cation and anions in 1980, 1981, and 1982. These results have been compared to 1965 trace element monitoring conducted by the same researchers.

Potential natural sources of acidity in soils, waters, and the atmosphere have been assessed, including symbiotic and non-symbiotic fixation of nitrogen, organic matter decomposition, fertilizer-soil chemical reactions, and ammonia ( $\text{NH}_3$ ) and ammonium ion ( $\text{NH}_4^+$ ) reactions in the atmosphere.

Eighty five percent of the agricultural soils in southern California have been characterized to date. In an attempt to develop a methodology for identifying soil sensitivity, multiple regression analyses will be run to correlate soil physical and chemical properties to soil buffering properties, considering such factors as cation exchange capacity, percent organic material, exchangeable bases, exchangeable acids, soil texture, and soil surface area.

A watershed study is currently being initiated for one or two catchment basins in the Sierra-Nevada Mountains. Total inputs and outputs of  $\text{H}^+$  will be determined. Wet and dry deposition will be collected at up to four sites. Ideally, the buffering capacity of the lakes and lands will be related to atmospheric acid deposition to determine whether the watershed might be adversely affected.

Expected Output/Delivery Dates:

Periodic progress reports will be supplied to the funding organization. Peer-reviewed articles will be submitted.

Project Title:

Assessment of the Cause of Rainbow Trout Mortalities in Aquaculture  
Facilities in the Raven Fork Watershed, Cherokee, NC (EE35)

Funding Organization:

Tennessee Valley Authority, Office of Power

Project Officer:

George J. Hyfantis, Jr.  
Tennessee Valley Authority  
127 Evans Building  
Knoxville, TN 37902  
(615) 632-6744

Research Organization and Principal Investigators:

Water Quality

Harvey Olem  
Tennessee Valley Authority  
248 401 Building  
Chatanooga, TN 37401  
(615) 751-7323

Fisheries

Richard Young  
Tennessee Valley Authority  
E&D Building  
Muscle Shoals, AL 35660  
(205) 386-2067

Terrestrial

J.M. Kelly  
Tennessee Valley Authority  
ORNL-ARP  
Building 1505  
Oak Ridge National Laboratory  
Oak Ridge, TN 37230  
(615) 574-7815

Period of Performance:

January 1982 through October 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$300,000*	
				(\$50,000)**	

\*funding also supplied by the U.S. Congress  
\*\* funds related to acid deposition

Research Objectives:

The objectives of this study are to determine the cause of rainbow trout mortalities in an aquaculture facility located in the Raven Fork watershed and to determine if acidic deposition is a significant contributing factor to observed adverse transient water quality conditions.

Project Description:

A mobile fisheries bioassay laboratory has been established in the vicinity of the aquaculture facility. Studies will be performed to determine the acute effects of:

- The rate, magnitude, and duration of pH change.
- Acute effects of aluminum.
- The combined or synergistic effect of pH and aluminium.

A gauging station and automatic water quality monitors and collectors have been installed to monitor and collect samples during rainfall events over the entire hydrograph. Similar automated monitors are located in an adjacent watershed not experiencing significant pH depression following rainfall events.

Wetfall/dryfall monitors have also been established at three different elevations in the watershed. Soils in the watershed will be characterized as well as vegetation and geologic characteristics. Changes in soil solution chemistry will be quantified in a select representative area of the watershed.

Expected Output/Delivery Date:

A report indicating preliminary findings will be prepared in October 1982.

Project Title:

Alternative Explanations for Aquatic Ecosystem Effects Attributed  
to Acidic Precipitation (EE36)

Funding Organization:

Utility Air Regulatory Group - Committee on Acid Deposition

Project Officer:

Althea Mitchell  
Hunton & Williams  
1919 Pennsylvania Avenue, N.W.  
Washington, D.C. 20036  
(202) 223-8650

Research Organization and Principal Investigators:

Walter C. Retzsch  
A. G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

March 1981 through March 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		- not available -			

Research Objectives:

The purpose of this report was to review conclusions presented in the New York State Department of Environmental Conservation's report entitled, "Acidity Status of Lakes in the Adirondack Region of New York in Relation to Fish Resources," by Pfeiffer and Festa (1980), and to evaluate other factors, aside from acidic precipitation, that may be responsible for the decline or absence of fish stocks from some Adirondack waters.

Project Description:

Declining fish stocks or the absence of fish from certain lakes may result from a complex association of natural and anthropogenic influences. The following factors were evaluated:

- Natural acidification and intolerable environmental conditions.

- Changes in fish stocking and management efforts.
- Regional development and increased recreational activities.
- Alterations of natural habitats resulting from construction of dams that manipulate stream flow or lake levels.

Output/Delivery Date:

A final report was published during March 1982.

Project Title:

Materials Damage from Acid Deposition (EE37)

Funding Organization:

Western Energy Supply and Transmission (WEST) Associates

Project Officer:

R.E. Erbes  
Public Service Company of New Mexico  
Alvarado Square  
Albuquerque, NM 87158  
(505)848-2014

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

June 1982 through December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$35,000	

Research Objectives:

The objectives of this study are :

- To summarize the state of knowledge concerning affects of dry and wet acid deposition on archaeological and geological resources in the southwest.
- To develop lab or field experiments to further the state of knowledge.

Project Description:

The project consists of the following major elements:

- Identification of archaeological and geological items of interest (e.g., Canyonlands National Park) in the southwest region, including typical materials (rock types) in these regions. From the list, a few representative rock types will be selected for extensive description.
- The available literature will be reviewed, including interviews with recognized experts and unpublished studies.

The literature related to the effects of southwestern atmospheres on archaeological and geological resources will be summarized. Natural weathering, as well as potential acid effects, will be described.

- The physical-chemical processes of natural weathering and acid effects as specifically related to the southwestern environment, and the specific rock types selected for the study, will be described.
- Laboratory studies that may be able to further the state of knowledge in this specific area will be designed.

Expected Output/Delivery Date:

A final report is due in December 1982.

Project Title:

Evaluating the Impact of Acid Precipitation on Several Northern Wisconsin Lakes (EE38)

Funding Organization:

Wisconsin Public Service Corporation

Project Officer:

E.N. Newman  
Wisconsin Public Service Corporation  
P.O. Box 1200  
Green Bay, WI 54305  
(414) 433-1294

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

May 1980 through May 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$10,000	\$12,000	\$12,000	

Research Objective:

The objective of this study is to identify the potential impacts of acid precipitation on 13 lakes in Vilas county of northern Wisconsin.

Project Description:

Lake samples are collected each month and analyzed for nutrients, heavy metals, and pH-alkalinity. Snow, rain and snow melt were also monitored occasionally. These results will be compared with historical data and data being gathered by the Wisconsin Department of Natural Resources.

Expected Output/Delivery Dates:

Unknown at this time



**SECTION 3**

**EMISSIONS AND MONITORING (EM)**

Project Title:

Investigation of Visual Air Quality and Atmospheric Precipitation  
Near Anaconda, Montana (EM1)

Funding Organization:

Anaconda Copper Company

Project Officer:

John Moldovan  
Anaconda Copper Company  
555 17th Street  
Denver, CO 80217  
(303) 575-7941

Research Organization and Principal Investigator:

D.A. Hansen  
Environmental Research & Technology, Inc.  
2625 Townsgate Road  
Westlake Village, CA 91361  
(805) 497-0821

Period of Performance:

May 1980 through January 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$100,000	\$100,000		
		(\$30,000)*	(\$30,000)*		

Research Objective:

The objective of this study was to establish a precipitation chemistry data base for the area surrounding the Anaconda smelter for comparison with data from National Atmospheric Deposition Program (see Project EM37) sites in the region.

Project Description:

A six-station network using wet-only automated precipitation collectors was established to collect eleven weekly samples per site over the period 21 September 1980 through 27 May 1981. Samples were analyzed for pH, conductivity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,

\*planned funding

$\text{PO}_4^{3-}$ ,  $\text{NH}_4^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ , and  $\text{K}^+$ . Analyses were performed at the Environmental Research & Technology laboratory in Westlake Village, California.

Output/Delivery Date:

A final report was submitted in January 1982 as Environmental Research & Technology Document No. P-A086

Project Title:

Effects of Energy Production Emissions on Colorado Lakes (EM2)

Funding Organization:

Colorado-Ute Electric Association, Inc.

Project Officer:

Jerry Walker  
Manager, Environmental Services  
Colorado-Ute Electric Association, Inc.  
P.O. Box 1149  
Montrose, CO 81402  
(303) 249-4501

Research Organization and Principal Investigator:

John Turk  
United States Geological Survey  
Building 53, Mail Stop 415  
Denver Federal Center  
Lakewood, CO 80225  
(303) 234-3487

Period of Performance:

August 1981 through August 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$8,200		

Research Objective:

The purpose of this study is to monitor atmospheric deposition to obtain accurate estimates of both wet and dry deposition in the vicinity of several coal-fired power plants and near an area of oil shale development. This monitoring is closely tied to a United States Geological Survey (USGS) study related to the effects of atmospheric deposition on high elevation lakes on Grand Mesa.

Project Description:

Colorado-Ute is providing funds for the operation of one precipitation chemistry monitoring site on Grand Mesa, 15 miles southeast of Grand Junction. This site is part of a four station network equipped and operated by the USGS. Wet and dry deposition are sampled with variable frequency using Leonard Mold and Die collectors. Samples are analyzed for pH, acidity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,

$\text{NO}_2^-$ ,  $\text{NH}_4^+$ , organic N,  $\text{Br}^-$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$  at the USGS laboratory in Denver. In addition, precipitation rate and volume, long and short wave radiation, wind speed and direction, and temperature are monitored. Also, data from detailed meteorological and upper air studies conducted at 12 Colorado-Ute meteorological stations are being supplied to the USGS.

Expected Output/Delivery Dates:

Annual summary reports are produced.

Project Title:

Purdue University Coal Research Center Acid Rain Project (EM3)

Funding Organization:

Conoco Inc.

Project Officer:

Flynt Kennedy  
Manager, Coal Research Division  
Conoco Inc.  
Library, PA 15129  
(412) 831-6600

Research Organization and Principal Investigator:

Jack Yost  
School of Health Science  
Purdue University  
West Lafayette, IN 47907  
(317) 494-1445

Period of Performance:

June 1980 through 1 August 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$21,200	\$42,000	\$36,000	

Research Objective:

The objective of this project is to analyze selected acid deposition chemistry and transport data.

Project Description:

The following tasks are being performed:

- Screening of New York State U.S. Geological Survey Precipitation Monitoring Network 1965 - 1979 data for outliers using ion balance and conductivity methods.
- Development of a "close in" pseudo-Gaussian air diffusion model to assess local deposition as compared to long-range transport determined by the RAPT Long-Range Transport Model of Battelle Pacific Northwest Laboratories.

- Monitoring of precipitation chemistry using National Atmospheric Deposition Program (NADP) (see Project EM37) protocol and tracking of events using trajectory analysis.

Expected Output/Delivery Dates:

An article entitled "Quality Analysis of USGS Precipitation Data for New York" by L.G. Miles and Jack Yost has been accepted for publication by Atmospheric Environment (1982).

Outputs for the other tasks have not yet been determined.

Project Title:

Temporal Variations of Acid Precipitation in the U.S. Geological Survey's New York State Precipitation Monitoring Network (EM4)

Funding Organizations:

Conoco Inc.  
Consolidation Coal Company

Project Officer:

Richard Bilonick  
Consolidation Coal Company  
1800 Washington Road  
Pittsburgh, PA 15243  
(412) 831-4000

Research Organizations and Principal Investigators:

Duane G. Nichols  
Coal Research Division  
Conoco, Inc.  
Library, PA 15129  
(412) 831-6614

Richard Bilonick  
Consolidation Coal Company  
1800 Washington Road  
Pittsburgh, PA 15243  
(412) 831-4000

Period of Performance:

October 1981 through April 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$10,000	\$10,000	

Research Objective:

The objective of this research was to analyze (temporally and spatially) data from the U.S. Geological Survey New York State Precipitation Monitoring Network.

Project Description:

Two specific research tasks were performed:



- Task 1. An attempt was made to spatially map  $H^+$  data for each of 22 network sites for each year during 1965-1971.
- Task 2. Auto-regression analyses and time-series analysis methods were used to investigate temporal trends of  $H^+$ ,  $SO_4^{2-}$ ,  $NO_3^-$ , and  $Ca^{2+}$ , after data were screened using ion balance and conductivity checks.

Expected Output/Delivery Dates:

Two papers have been submitted to scientific journals:

- "The Applicability of Risk Qualified Mapping to Acidic Precipitation - An In-Depth Analysis of Mapping the New York USGS Data" by Richard Bilonick and Andre G. Journal (submitted to Environmental Science and Technology).
- "Temporal Variations in Acid Precipitation Over New York State" by Duane G. Nichols and Richard Bilonick (submitted to Atmospheric Environments).

Project Title:

1981 OSCAR Field Program Hydrogen Peroxide ( $H_2O_2$ ) Measurements  
(EM5)

Funding Organizations:

Coordinating Research Council, Inc. with financial support provided  
on a 50/50 basis by the American Petroleum Institute (API) and the  
Motor Vehicle Manufacturers Association

Project Officer:

Robert A. Gorse, Jr.  
Ford Motor Company  
Scientific Research Laboratories  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 323-1719

Research Organization and Principal Investigator:

Gregory L. Kok  
National Center for Atmospheric Research  
P.O. Box 3000  
Boulder, CO 80307  
(303) 494-5151

Period of Performance:

March 1981 through December 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$24,000		

Research Objective:

The objective of the work was to provide analytical data on  
hydrogen peroxide ( $H_2O_2$ ) concentrations in gas- and liquid-phase  
samples for the 1981 OSCAR (Oxidation and Scavenging  
Characteristics of April Rains) field program conducted by the U.S.  
Environmental Protection Agency (EPA) and the U.S. Department of  
Energy (DOE) in the eastern United States.

Project Description:

The following measurements of  $H_2O_2$  were taken:

- Continuous measurements of equivalent gas phase  $H_2O_2$  from 10 April to 22 April 1981.
- Measurements of  $H_2O_2$  in 41 precipitation samples and three cloud water samples.
- Measurements of  $H_2O_2$  in 66 cloud water simulator samples.<sup>4</sup>

Output/Delivery Date:

Measurements were incorporated within the context of the entire OSCAR program. A final report documenting the study was published in March 1982.

Project Title:

Captive Air Experiments in Support of Photochemical Kinetic Model  
Validation and Development and Empirical Kinetic Modeling Approach  
(EKMA) Evaluation (EM6)

Funding Organizations:

Coordinating Research Council, Inc., with financial support  
provided on a 50/50 basis from the American Petroleum Institute  
(API) and the Motor Vehicle Manufacturers Association

Project Officers:

Alan M. Dunker  
Research Laboratories  
General Motors Corporation  
12 Mile and Mound Roads  
Warren, MI 48090  
(313) 575-3263

Hiroshi Niki  
Scientific Research Staff  
Ford Motor Company  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 337-8322

Research Organization and Principal Investigator:

Allan C. Lloyd  
General Manager - Westlake Village Office  
Environmental Research & Technology, Inc.  
2625 Townsgate Road, Suite 360  
Westlake Village, CA 91361  
(805) 497-0821

Period of Performance:

June 1981 through August 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$125,000	\$125,000	
			(\$41,250)*	(\$41,250)*	

Research Objective:

The purpose of this study was to conduct an air measurement program  
in Los Angeles in support of photochemical kinetic model validation  
and development, as well as evaluation of the Environmental  
Protection Agency's (EPA) Empirical Kinetic Modeling Approach  
(EKMA). Since the EKMA concept relies heavily on chemical

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\*funds related to acid deposition

mechanisms to relate ozone ( $O_3$ ) to its precursors, it was of major importance that the photochemistry and its application in EKMA be examined in detail against real atmospheric observations.

#### Project Description:

The first phase of the experiments conducted by Environmental Research & Technology, with active participation from the University of Michigan (see Project EM10) and Unisearch Associates (see Project EM9), covered a 7-week period (September-November 1981) during the height of the Los Angeles smog season. To obtain the necessary data, ambient air was collected on a rooftop site at the University of Southern California in downtown Los Angeles during the early morning hours and irradiated in one large and four satellite outdoor bags. Concentrations measured included nitric oxide (NO), nitrogen dioxide ( $NO_2$ ), peroxyacetylnitrate (PAN), individual hydrocarbons and aldehydes, and total nonmethane hydrocarbons. Upon data reduction and plotting, the  $O_3$  measurements made during this project were compared with isopleths generated for the Los Angeles area during October 1981 with different chemical mechanisms (including the EKMA mechanism) to ascertain which mechanism performs better. Results of the program will include an interlaboratory comparison of the measurement methods used at the test site by Environmental Research & Technology, the University of Michigan, and Unisearch Associates. As a matter of course, the data obtained by the three laboratories will be shared and utilized for modeling where applicable. The possible application of the captive air approach for assessing pollutant control measures in other areas of the country was analyzed.

#### Output/Delivery Dates:

A final report detailing all of the work performed, including data, analyses, interpretations, recommendations, and conclusions was published in July 1982.

Project Title:

Critical Evaluation and Comparison of Measurement Methods for  
Nitrogenous Compounds in the Atmosphere (EM7)

Funding Organizations:

Coordinating Research Council, Inc., with financial support  
provided on a 50/50 basis by the American Petroleum Institute (API)  
and the Motor Vehicle Manufacturers Association

Project Officer:

Hiromi Niki  
Scientific Research Staff  
Ford Motor Company  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 337-8322

Research Organization and Principal Investigator:

Daniel Grosjean  
Technical Director  
Applied Research Operations  
Environmental Research & Technology, Inc.  
2625 Townsgate Road, Suite 360  
Westlake Village, CA 91361  
(213) 889-5313

Period of Performance:

July 1980 through October 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$35,800	\$59,800		
		(\$17,900)*	(\$29,900)*		

Research Objective:

This study was conducted to provide an assessment of current  
methods employed for the determination of key nitrogen-containing  
compounds in the atmosphere.

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\*funds related to acid deposition

Project Description:

An intensive field study of atmospheric nitrogenous pollutants was conducted in Claremont, California, during selected September and October 1980 photochemical episodes. Parameters measured included nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>), peroxyacetyl-nitrate (PAN), and nitric acid (HNO<sub>3</sub>). In addition, a search for gaseous and particulate organic nitrates was conducted, and a limited number of refined particulate samples collected on quartz filters were analyzed for sulfate (SO<sub>4</sub><sup>2-</sup>) and total carbon. Field operations included continuous monitoring of NO, NO<sub>2</sub>, and PAN, as well as the collection of 250 Teflon, nylon, and quartz filter samples on 16 selected days, which included the most severe 1980 photochemical episodes in the Los Angeles area (ozone  $\geq$  0.4 ppm). The sampling protocol employed included a range of sampling times, flow rates, and atmospheric conditions (daytime as well as nighttime sampling).

Output/Delivery Date:

A final report entitled "Critical Evaluation and Comparison of Measurement Methods for Nitrogenous Compounds in the Atmosphere" was published in January 1982.

Project Title:

Detection of Atmospheric Nitrogen Dioxide (NO<sub>2</sub>) by Intracavity  
Photoacoustic Laser Spectroscopy (EM8)

Funding Organizations:

Coordinating Research Council, Inc., with financial support  
provided on a 50/50 basis by the American Petroleum Institute (API)  
and the Motor Vehicle Manufacturers Association

Project Officer:

Hiromi Niki  
Scientific Research Staff  
Ford Motor Company  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 337-8322

Research Organization and Principal Investigator:

George H. Atkinson  
Associate Professor of Chemistry  
Syracuse University  
108 Bowne Hall  
Syracuse, NY 13210  
(315) 423-3238

Period of Performance:

April 1980 through September 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$72,300	\$96,400	\$117,232	\$44,935
		(\$18,075)*	(\$24,100)*	(\$29,308)*	(\$11,234)*

Research Objective:

The objective of this study is to develop a method for examining NO<sub>2</sub> samples at total pressures of one atmosphere by means of intracavity photoacoustic laser spectroscopy in the visible spectral regions. The results of this work will provide the basis for accurate atmospheric measurements of nitrogen dioxide (NO<sub>2</sub>) by photoacoustic instrumentation given the specific sensitivity,

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\*funds related to acid deposition



dynamic range, and chemical complexity of the sample. It will also serve to provide the basis for designing future field measurement programs where potential interferences can be definitively treated.

Project Description:

Early work covered the characterization of the photoacoustic signal for  $\text{NO}_2$  over the entire  $\text{NO}_2$  absorption spectrum to achieve:

- Optimization of the experimental conditions for detection.
- Optimization of a multiple channel configuration for direct reading of  $\text{NO}_2$ .
- Improvement of the digital storage and computer analysis capabilities of the proposed instrumentation.

Efforts were also made to identify  $\text{NO}_2$  by the use of phase-shift data, as well as by differences in optical absorption. In the second phase of this study, a small-scale field measurement program was conducted.

Laboratory experiments continue in order to evaluate which spectral regions are most useful for  $\text{NO}_2$  detection at atmospheric pressures and to identify interfering species [nitrate ( $\text{NO}_3^-$ ), nitrous acid ( $\text{HNO}_2$ ), nitric acid ( $\text{HNO}_3$ ), and ozone ( $\text{O}_3$ )], based on differences in optical absorption spectra and phase-shifts arising from distinct excited state decay mechanisms.

Expected Output/Delivery Dates:

A report detailing the first year research effort has been published. Reports covering the remaining research are scheduled for publication in September 1982 and September 1983.

Project Title:

Measurement of Nitric Oxide (NO), Nitrogen Dioxide (NO<sub>2</sub>), and  
Nitric Acid (HNO<sub>3</sub>) Using a Tunable Diode Laser System (EM9)

Funding Organizations:

Coordinating Research Council, Inc., with financial support  
provided on a 50/50 basis from the American Petroleum Institute  
(API) and the Motor Vehicle Manufacturers Association.

Project Officer:

Hiromi Niki  
Scientific Research Staff  
Ford Motor Company  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 337-8322

Research Organization and Principal Investigator:

Harold I. Schiff, President  
Unisearch Associates, Inc.  
222 Snidercroft Road  
Concord, Ontario  
Canada L4K 1B5  
(416) 669-2280

Period of Performance:

September 1980 through September 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$31,000	\$125,000	\$81,000	(\$94,000)**
		(\$23,250)*	(\$93,750)*	(\$60,750)*	(\$70,500)*,**

Research Objective:

The purpose of this study is to investigate the feasibility of a  
tunable diode laser system for measuring nitric oxide (NO),  
nitrogen dioxide (NO<sub>2</sub>), and nitric acid (HNO<sub>3</sub>) in ambient air, with  
detection limits better than 0.5 ppbv.

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\*funds related to acid deposition

\*\*planned funding

Project Description:

The first phase of the work was conducted with a laboratory prototype of the system. Since  $\text{HNO}_3$  is the least abundant of the three nitrogen compounds and was the one for which the greatest sampling and calibration problems were anticipated, considerable effort was expended on this compound. Subsequently, a portable field instrument incorporating the diode laser system was constructed for use in comparison measurements with the University of Michigan chemiluminescent apparatus (see Project EM10), and to participate in the September-November 1981 captive air measurement study (see Project EM6).

Expected Output/Delivery Dates:

A report documenting the development of the field instrument and participation in the captive air experiment was completed in August 1982. A final report is scheduled for September 1983.

Project Title:

Measurements Related to Atmospheric Oxides of Nitrogen (EM10)

Funding Organizations:

Coordinating Research Council, Inc., with financial support provided on a 50/50 basis from the American Petroleum Institute (API) and the Motor Vehicle Manufacturers Association

Project Officer:

Hiromi Niki  
Scientific Research Staff  
Ford Motor Company  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 337-8322

Research Organization and Principal Investigator:

Donald H. Stedman  
Associate Professor of Atmospheric Chemistry  
University of Michigan  
Space Physics Research Laboratory, Room 1206  
Ann Arbor, MI 48109  
(313) 763-6239

Period of Performance:

April 1980 through September 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$70,000	\$93,600	\$70,000	
		(\$23,100)*	(\$30,889)*	(\$23,333)*	

Research Objectives:

In September 1980, the University of Michigan's Mobile Air Quality Laboratory conducted a 3-week field measurement program at the Harvey Mudd College campus site in Claremont, California, downwind of Los Angeles. The three objectives of this study were:

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\*funds related to acid deposition

- To demonstrate the ability to measure atmospheric nitric oxide (NO), nitrogen oxides (NO<sub>x</sub>), gaseous nitric acid (HNO<sub>3</sub>), ozone (O<sub>3</sub>), and nitrogen dioxide (NO<sub>2</sub>) photolysis rate reliably under field conditions, with good time resolution and over an extended period.
- To obtain data to compare models which predict HNO<sub>3</sub>/NO<sub>x</sub> ratios.
- To obtain data to compare with models of the NO/NO<sub>2</sub>/O<sub>3</sub> photostationary state, and to estimate peroxy radical concentrations from the departure from unity of the photostationary state ratio p in polluted air.

#### Project Description:

Observations of NO, NO<sub>x</sub>, HNO<sub>3</sub>, j(NO<sub>2</sub>), and O<sub>3</sub> were recorded approximately once per minute and subsequently analyzed on a computer at the University of Michigan. Calibration was done periodically onsite using standard cylinders of NO and NO<sub>2</sub>, a diffusion tube HNO<sub>3</sub> source calibrated against a pH meter, and a UV O<sub>3</sub> source calibrated against a long-path UV absorption O<sub>3</sub> detector. Because the original data set was unwieldy, the data were converted in terms of hour averages.

In other work under this contract, the University of Michigan participated in a captive air measurement program (see Project EM6) in Los Angeles in support of photochemical kinetic model validation and development, as well as evaluation of the Environmental Protection Agency's (EPA) Empirical Kinetic Modeling Approach (EKMA).

#### Output/Delivery Dates:

A final report entitled "Measurements Related to Atmospheric Oxides of Nitrogen," documenting the 1980-1981 study, has been published. University of Michigan participation in the captive air experiment was documented in a final report scheduled for publication in September 1982.

Project Title:

Testing Emissions Scenarios for Control of Acid Deposition (EM11)

Funding Organization:

Detroit Edison Company, Engineering Research Department

Project Officer:

Michael F. Rodenberg  
Detroit Edison Company  
2000 Second Avenue  
Detroit, MI 48226  
(313) 897-1331

Research Organization and Principal Investigator:

Perry J. Samson  
Department of Atmospheric and Oceanic Sciences  
2455 Hayward  
University of Michigan  
Ann Arbor, MI 48109  
(313) 764-3335

Period of Performance:

1 June 1982 through 30 August 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$50,000	\$27,000*

Research Objectives:

Research objectives of this project are:

- To determine the relative consequences of emission reductions in Michigan on specific sensitive areas selected by the U.S. Environmental Protection Agency (EPA).
- To estimate the net reductions in ambient sulfate ( $\text{SO}_4^{2-}$ ) concentrations and sulfate wet deposition amounts downwind of the state of Michigan due to reductions in emissions of sulfur dioxide ( $\text{SO}_2$ ), nitrogen oxides ( $\text{NO}_x$ ) and hydrocarbons (HC) within the state.

\*planned funding

- To compare linear chemical results with non-linear chemical results.

Project Description:

The following tasks are indicated by year:

- 1982
  - Estimate the net reductions in ambient  $\text{SO}_4^{2-}$  concentrations and  $\text{SO}_4^{2-}$  wet deposition amounts downwind of Michigan resulting from reduced  $\text{SO}_2$ ,  $\text{NO}_x$ , and HC emissions in Michigan.
  - Model and compare emission reduction scenarios and their impacts using linear and non-linear approaches.
  - Estimate impacts due to Michigan episodes.
  - Compare linear and non-linear methodologies for long range transport modeling.
- 1983
  - Compare calculated episode values with measured values at several SURE (see Project EM18) Class I sites.
  - Develop estimates along trajectories of  $\text{NO}_x$ ,  $\text{SO}_2$  and HC emissions for eastern North America.
  - Compare various parameters for correlation to high  $\text{SO}_4^{2-}$  values.

Expected Output/Delivery Date:

Final report, June 1983

Project Title:

Utility Acid Precipitation Study Program (UAPSP) (EM12)

Funding Organizations:

The project is funded by an ad-hoc group of electric utilities, with administrative staff functions provided through the Edison Electric Institute (EEI) and technical management provided by the Electric Power Research Institute (EPRI).

Project Officer:

Susan F. Farrell  
Environmental Scientist  
Edison Electric Institute  
1111 19th Street, N.W.  
Washington, D.C. 20036  
(202) 828-7622

Research Organizations and Principal Investigators:

Network Operation

Leo Topol  
Rockwell International Corporation  
Environmental Monitoring and Services Center  
2421 West Hillcrest Drive  
Newbury Park, CA 91320-2299  
(805) 498-6771

Quality Assurance

Cary Eaton  
Research Triangle Institute  
P.O. Box 12194  
Research Triangle Park, NC 27709  
(919) 541-6000

Workshop

R.J. Hoch, President  
Sigma Research, Inc.  
2950 George Washington Way  
Richland, WA 99352  
(509) 375-0663

Period of Performance:

19 August 1981 through 31 December 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$184,000	\$620,760	\$1,121,000*

\*planned funding



### Research Objectives:

The objective of this project are to monitor the occurrence of acid precipitation in the United States and determine the relationships between acidity, rain chemistry, meteorologic conditions, and emission source distributions.

### Project Description:

Wet-only samples will be collected daily at 19 sites concentrated in the eastern United States using automated wet/dry precipitation samplers. Two sites will operate duplicate collectors as internal reproducibility checks. Field operators will measure sample weight, pH and conductivity. Lab analyses will include pH, conductivity, weight,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{Ca}^{2+}$ ,  $\text{K}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$  and  $\text{NH}_4^+$ . Statistical tests, including correlations, regressions, and factor analysis, will be used to identify relationships between precipitation acidity and chemistry, meteorological and climatological conditions, and topographic features.

An independent contractor will provide Quality Assurance services for the network operations. These services include documentation and procedure reviews, evaluation of inherent limitations, and on-site and mail-out performance audits. The UAPSP data will be compared with data from the Multi-State Atmospheric Power Production Study (MAP3S) of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE), the Wisconsin Utilities Association's Deposition Monitoring Network (see Project EM42), and the Florida Electric Power Coordinating Group's Acid Deposition Monitoring Program (see Project EM21).

Also, a workshop was sponsored during 10-12 August 1982, entitled "Workshop on Methods for Comparing Precipitation Chemistry Data," with an objective of identifying and recommending methods for determining comparability between precipitation chemistry networks. Four working groups addressed:

- Quality Control/Quality Assurance procedures.
- Use of Quality Control/Assurance information.
- Intercomparison study needs.
- Data archiving and documentation needs.

Representatives from most of the larger precipitation chemistry networks in the U.S. and Canada were in attendance.

Expected Output/Delivery Date:

First annual report, September 1982  
Design and implementation plan, December 1982  
Laboratory procedures manual, December 1982  
Field operators manual, December 1982  
Quality control manual, December 1982  
External quality assurance plan, December 1982  
Workshop final report, December 1982  
Final report(s), mid 1985

Project Title:

Acid Precipitation in the Northeastern United States (EM13)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Charles Hakkarinen  
Energy Analysis and Environment Division  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2592

Research Organization and Principal Investigator:

Leo Topol  
Rockwell International Corporation  
2421 West Hillcrest Drive  
Newbury Park, CA 91320  
(805) 498-6771

Period of Performance:

2 May 1978 through 31 March 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$450,000	\$48,000			

Research Objectives:

The project objectives were:

- To monitor the amount and chemical nature of precipitation falling within the Sulfate Regional Experiment (SURE) study (see Project EM18) region and determine its total and strong acid components.
- To correlate observed changes in precipitation acidity with geographical, temporal, and meteorological conditions.
- To identify regional source-receptor relationships between emissions of substances found in precipitation and deposition patterns.

Project Description:

Precipitation was collected on a daily basis at nine locations (Class I SURE stations) in the eastern United States and chemically analyzed for pH, acidity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ , dissolved organic carbon,  $\text{Al}^{3+}$ , total acidity, and strong acidity. Air mass trajectories of storms were calculated and correlations made between observed deposition patterns and regional emissions as calculated during the Sulfate Regional Experiment (SURE) emissions inventory (see Project EM18).

Measurements for this network began in August of 1978 and continued through June of 1979, at which time operations were expanded to cover 15 sites and the network became part of EPRI Eastern Regional Air Quality Study (ERAQS) (see Project EM16).

Output/Delivery Date:

Work was continued and expanded under another project (see Project EM17) during July 1979. No final report was published for this project.

Project Title:

Acidic Precipitation in the Adirondack Region (EM14)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Charles Hakkarinen  
Energy Analysis and Environment Division  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94304  
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Research Organization and Principal Investigator:

Nicholas Clesceri  
Rensselaer Polytechnic Institute  
Department of Chemical and Environmental Engineering  
101 Eighth Street  
Troy, NY 12181  
(518) 270-6541

Period of Performance:

17 October 1977 through 31 August 1980

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$310,000	\$40,000			

Research Objectives:

Research objectives of this project were:

- To provide accurate input information regarding precipitation quality and quantity to concurrent effects research projects at three Adirondack watersheds (see Project EE19).
- To investigate the validity of the hypothesis that the three lakes receive the same inputs of the various chemical species.

Project Description:

Atmospheric inputs into three lake watersheds within a 30 km radius of each other in the Adirondack Park region of New York state were quantified for the period May 1978 through August 1979. This was

accomplished with a wet/dry precipitation network with samples collected on an event basis. Rain and snow amounts were measured and samples were analyzed for pH, conductivity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{NH}_4^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$ , and  $\text{Na}^+$ .

The contribution of dry deposition to total atmospheric loadings in the three basins was investigated. Also, the relative importance of  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$  species was analyzed via  $\text{SO}_4^{2-}/\text{NO}_3^-$  ratios in wet deposition. Finally, the modification of wet deposition by the forest canopy was researched.

Output/Delivery Date:

A final report, entitled "Characterization of Acidic Precipitation in the Adirondack Region," was published in May 1981 as Electric Power Research Institute (EPRI) document EA-1826.

Project Title:

Development of a Method to Measure Hydrogen Peroxide (H<sub>2</sub>O<sub>2</sub>) in Air,  
Cloudwater, and Rainwater (EM15)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

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Environmental Physics and Chemistry Program  
Electric Power Research Institute  
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Research Organization and Principal Investigator:

Allan L. Lazrus  
National Center for Atmospheric Research  
P.O. Box 3000  
Boulder, CO 80307  
(303) 494-5151

Period of Performance:

15 April 1981 through 15 July 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$80,000	\$39,000	

Research Objectives:

The objectives of this research project were:

- To develop and test a new method for the measurement of hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) from an aircraft. This method would be applicable to ambient air, cloudwater, and rainwater samples.
- To field test this new method during one or more 1981 field experiments.
- To intercompare this new method with other current methods.

Project Description:

The following tasks were undertaken:

- Task 1. Development of Automated  $H_2O_2$  Technique. An automatic technique for the measurement of  $H_2O_2$  in air, cloudwater, and rainwater from an aircraft was developed and tested. The basis of the method was the oxidation of homovanillic acid to its dimer by hydrogen peroxide in an enzyme catalyzed reaction using horse radish peroxidase. The removal of interferences, especially that from sulfur dioxide ( $SO_2$ ), was addressed. The device was tested in the laboratory and its sensitivity and accuracy limits determined.
- Task 2. Field Testing. The final automated system was field tested aboard the National Center for Atmospheric Research (NCAR) Queen Air aircraft.
- Task 3. Intercomparison Tests. The final system was inter-compared with current and past  $H_2O_2$  measurement techniques in the laboratory and in the field during the Task 2 tests.

Output/Delivery Date:

A final report was produced in July 1982.



Project Title:

Precipitation Chemistry Measurements - Eastern Regional Air Quality  
Studies (ERAQS) (EM16)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Peter K. Mueller  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2586

Research Organization and Principal Investigator:

Leo Topol  
Rockwell International Corporation  
Environmental Monitoring Services Center  
2421 West Hillcrest Drive  
Newbury Park, CA 91320-2299  
(805) 498-6771

Period of Performance:

1 July 1979 through 30 June 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$261,000	\$229,000	\$241,000		

Research Objective:

It was the purpose of this project to provide precipitation chemistry measurements in the eastern United States. From October 1981 to April 1984, network operations are being funded by the Utility Acid Precipitation Study Program (see Project EM12), with EPRI acting as the project manager.

Project Description:

Precipitation samples will be gathered on an event basis, and if of sufficient quantity, will be submitted to Rockwell International's analytical laboratory for chemical analyses.

Samples will be measured in the field immediately after collection for volume, pH, and conductivity. Samples will be refrigerated after collection and shipped cold to the laboratory for chemical analysis of  $\text{Al}^{+3}$ ,  $\text{Ca}^{+2}$ ,  $\text{Cl}^{-}$ ,  $\text{K}^{+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^{+}$ ,  $\text{NH}_4^{+}$ ,  $\text{PO}_4^{3-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^{-}$ , total and strong acidity, and dissolved organic carbon. Sample quantity, pH, and conductivity will be remeasured in the laboratory.

A quality assurance plan will be implemented, which includes, but is not necessarily limited to: collector cleaning; sample identification; handling and transport; sample analyses; and data handling and reporting.

Data will be reported on an event basis, aggregated by station during each three month period beginning 1 July 1979. All data will be reported within three months after each quarter. All data will be reported in hard copy as well as on computer tape (IBM compatible, 9-track ASCII format).

Expected Output/Delivery Dates:

The final report for monitoring through 30 September 1981 will be published by December 1982.

Project Title:

Source Emissions Inventories for the Eastern and Western Regional  
Air Quality Studies (EM17)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Robert Patterson  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2581

Research Organization and Principal Investigator:

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Environmental Research & Technology, Inc.  
696 Virginia Road  
Concord, MA 01742  
(617) 369-8910

Period of Performance:

July 1982 through 31 December 1984

<u>Funding</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$150,000	\$510,000

Research Objective:

The primary objective of this work is to derive estimates for anthropogenic source emissions of sulfur oxides (SO<sub>x</sub>), total emitted particulates (TEP), nitrogen oxides (NO<sub>x</sub>), and nonmethane hydrocarbons (HC).

Project Description:

This project will include an update and refinement of the inventory prepared for the Sulfate Regional Experiment (SURE) program (see Project EM18), and the development of a similar inventory for geographical areas not included in the SURE program.

Basic anthropogenic emissions inventories will be developed for SO<sub>x</sub>, TEP, NO<sub>x</sub>, and HC for the conterminous United States and parts of Canada, for each of the following source classifications:

- Fossil-fueled electric utility plants.
- Other major point sources.
- Minor point sources.
- Home heating.
- Surface transportation.

As a separate task, correlations between  $\text{SO}_x$ , TEP, HC, and  $\text{NO}_x$  emission rates and external factors (such as atmospheric temperature, wind velocity, cloud cover, and precipitation), economic indicators, and other factors will be developed for each source classification and, if necessary, by geographical region. These relationships, when substantiated, will be presented in a form suitable for modifying local seasonal emission rates in terms of observed values of the external factors. Also, the accuracy of techniques used to estimate source emissions for each pollutant and source will be verified.

These data, along with monitoring data from the EPRI Regional Air Quality Studies program (see Project EM16), will be used for interpreting causes of pollutant loadings and for the development of air quality models.

Expected Output/Delivery Date:

The final report is due in December 1984.

Project Title:

Sulfate Regional Experiment (SURE) (EM18)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Glenn R. Hilst  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2591

Research Organization and Principal Investigator:

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Environmental Research & Technology, Inc.  
2625 Townsgate Road  
Westlake Village, CA 91361  
(805) 497-0821

Period of Performance:

10 February 1975 through 31 December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$7,746,000	\$133,000	\$150,000	\$70,000	
	(\$1,936,500)*	(\$33,250)*	(\$37,500)*	(\$17,500)*	

Research Objectives:

The primary objectives of the Sulfate Regional Experiment (SURE) project were:

- To establish a regional air quality data base through measurements of several parameters at the ground and aloft, and evaluate the adequacy of the measurements selected for establishing the origins of the sulfur oxide (SO<sub>x</sub>) particulate complex.
- To establish the location and magnitude of emissions occurring during the air quality measurement period. In addition to

\*funds related to acid deposition

SO<sub>x</sub>, the emissions inventoried included nitrogen oxides (NO<sub>x</sub>), gaseous hydrocarbons (HC) and particulates.

- To derive a quantitative method for relating emissions from the electric power industry to regional ambient air quality as measured by sulfur dioxide (SO<sub>2</sub>) and particulate sulfate (SO<sub>4</sub><sup>2-</sup>), and to use this method to establish the relative importance of emission density distribution, meteorology, chemical transformations, and removal processes to the regional occurrence of SO<sub>x</sub> and NO<sub>x</sub>.

#### Project Description:

The monitored area for the SURE Project extended from eastern Kansas to the Atlantic seaboard and from mid-Alabama to southeastern Canada, an area of approximately 2400 km x 1000 km. The ground monitoring network for the SURE consisted of 9 Class I stations and 45 Class II stations. The Class I stations were instrumented to operate continuously for 19 months, measuring SO<sub>2</sub>, HIVOL total suspended particulates (TSP), NO/NO<sub>x</sub>, ozone (O<sub>3</sub>), sulfate, nitrate (NO<sub>3</sub><sup>-</sup>), and other supplemental parameters. Sulfates were measured to provide 24-hour averages daily and 3-hourly averages for 30 days for each of seven seasons to delineate the diurnal variations. Sulfates were also sampled in two-size fractions to delineate the magnitude of the refined suspended particulates (RSP).

The Class II stations were operated for only the central month of each season for seven seasons. Parameters measured were SO<sub>2</sub>, 24-hour average SO<sub>4</sub><sup>2-</sup>, and HIVOL TSP concentrations.

In addition to these air quality measurements, supporting meteorological data were obtained from existing National Weather Service (NWS) stations throughout the eastern half of the United States. The meteorological data consisted of hourly AIRWAYS synoptic observations, including radiosonde soundings.

A flight program was initiated to assist in defining the SO<sub>4</sub><sup>2-</sup> distribution so that model parameters, such as horizontal grid size and boundary concentrations, could be determined and model verification achieved. The vertical distribution of pollutants in the lower 3000 meters of the troposphere in the vicinity of two SURE Class I stations was measured during each of the seven SURE intensive study periods including measurements of air quality, meteorology, and aircraft position.

Extensive field measurements were performed in late spring and late fall of 1977 near two coal-fired and one oil-fired power plants.

Plume measurements included gas concentrations (SO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>, NH<sub>3</sub>,

HNO<sub>3</sub>, hydrocarbons), aerosol composition (SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>) and physical aerosol parameters. Source emission measurements were also performed and SF<sub>6</sub> tracer released into the plumes. The resulting data, which include 140 hours of aircraft measurements, were organized into a data base. Inventories were prepared for all man-made stationary sources of emissions and surface transportation emissions. Variations in emissions by season and for 3-hour periods throughout the day were reported. Estimates of emissions of SO<sub>2</sub>, SO<sub>4</sub><sup>2-</sup>, particulate matter, nitrogen monoxide, nitrogen dioxide, and three classes of hydrocarbons were prepared in each of five source classifications (electric utility, industrial, commercial, residential and transportation). Inventories of SO<sub>2</sub> and SO<sub>4</sub><sup>2-</sup> emissions from electric utility sources in the region were prepared for August and October 1977, 10 January to 9 February 1978, 3 April to 2 May 1978, and July 1978. Hourly variations on a point-by-point basis were reported. Relationships between emission rates and external factors (e.g., temperature and other meteorological parameters) were investigated for different source types. Finally, a detailed analysis of the accuracy of the emissions inventories was performed.

An important goal of the SURE was to develop a quantitative method that related air pollutant emissions from power plants to concentrations of particulates and SO<sub>2</sub>. A numerical grid model that related emissions and atmospheric processes to air quality over the SURE region was developed and evaluated. The model was designed to calculate SO<sub>4</sub><sup>2-</sup> and SO<sub>2</sub> concentrations for the following spatial constraints: (1) the SURE area, which was divided into 80 x 80 kilometer grids; and (2) five layers in the planetary boundary layer (0-50, 50-100, 100-300, 300-700 and 700-1500 meters above the ground).

The model was constructed to account for the following atmospheric processes:

- Horizontal advective transport.
- Turbulent diffusion.
- Effective emissions release height.
- Diurnally varying SO<sub>2</sub> to SO<sub>4</sub><sup>2-</sup> conversion rates.
- Seasonally varying SO<sub>2</sub> and SO<sub>4</sub><sup>2-</sup> dry deposition rates.

As outgrowth of the SURE project, further modelling efforts are being undertaken under the Regional Air Quality Study (ERAQS) of the Electric Power Research Institute.

#### Output/Delivery Dates:

Twenty-three technical reports have been completed by EPRI or the contractors to date.

Project Title:

Development and Evaluation of Cloud Water Collectors (EM19)

Funding Organizations:

This project is equally funded by the Electric Power Research Institute (EPRI) and the Coordinating Research Council, Inc., which is supported on a 50/50 basis by the American Petroleum Institute (API) and the Motor Vehicle Manufacturers Association

Project Officer:

Robert A. Gorse, Jr.  
Ford Motor Company  
Scientific Research Laboratories  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 323-1719

Research Organization and Principal Investigator:

David F. Miller, Director  
Air Resources Laboratory  
Desert Research Institute  
Atmospheric Sciences Center  
P.O. Box 60220  
Reno, NV 89506  
(702) 972-1676

Period of Performance:

October 1981 through April 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$14,600	\$116,800	

Research Objectives:

This study will be directed at the development and evaluation of cloud water collectors for ground based sampling.

Project Description:

The emphasis of this work is on the development of a cloud water collector to collect only cloud droplets to the exclusion of interstitial aerosols and raindrops. The successful development of



the cloud water collector will allow the consideration of future field studies to evaluate new theories of cloud chemistry and data of related laboratory studies. The cloud water collector will be evaluated during the summer of 1982 at Whiteface Mountain, New York, in cooperation with the Atmospheric Sciences Research Center, State University of New York at Albany.

Expected Output/Delivery Date:

Final report, May 1983

Project Title:

Acid Precipitation Monitoring (EM20)

Funding Organizations:

Empire State Electric Energy Research Corporation (ESEERCO)  
New York State Electric & Gas Corporation  
Niagara Mohawk Power Corporation

Project Officer:

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3890 Carmen Road  
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Research Organizations and Principal Investigators:

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John M. Toennies  
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(315) 474-1511

Period of Performance:

September 1978 through 31 December 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$54,000	\$54,000	\$54,000	\$54,000	\$54,000*

Research Objectives:

The objective of this project is to establish and maintain four wet/dry deposition monitoring stations under the auspices of the National Atmospheric Deposition Program (NADP), a national network

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\*planned funding

consisting of approximately 95 stations funded by government, educational, and private sector entities. Research objectives of the NADP are as follows:

- Establish an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States.
- Determine the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases in total atmospheric deposition throughout the United States.
- Develop optimum procedures for collecting precipitation and dry particulate matter.
- Determine the stability of certain constituents of precipitation during collection, transport, and storage prior to analysis.

Project Description:

Aerochem Metrics 201 wet/dry deposition collectors are utilized to collect weekly wet deposition and bimonthly dry deposition. Samples are shipped to the Illinois State Water Survey in Champaign, Illinois, where they are analyzed for pH, conductivity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$ .

Output/Delivery Dates:

Quarterly NADP data reports are issued from the Natural Resource Ecology Laboratory at Colorado State University in Fort Collins, Colorado.

Project Title:

Florida Acid Deposition Study  
Acid Deposition Monitoring Program (Program 1 of 4) (EM21)

Funding Organization:

Florida Electric Power Coordinating Group, Inc.  
402 Reo Street, Suite 214  
Tampa, FL 33609  
(813) 877-5301

Project Officer:

Charles D. Henderson  
Environmental Affairs Department  
Florida Power and Light Company  
P.O. Box 529100  
Miami, FL 33152  
(305) 552-4819

Research Organization and Principal Investigator:

E.R. Hendrickson  
Project Director  
Environmental Science & Engineering, Inc.  
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Gainesville, FL 32602  
(904) 372-3318

Period of Performance:

January 1981 through March 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$357,000	\$432,000	\$675,000*

Research Objectives:

The Florida Acid Deposition Study's primary objective is to assess and develop information needed to place the acid deposition issue in the proper perspective for Florida as to its magnitude, variability, sources, effects, and control options. The study is divided into four study programs (each program is described as a

\*planned funding

separate project in this document - consult the Funding Organization Index) and four time phases, to allow periodic reassessment of the desirability of continuing funding or changing direction.

The specific objectives of the Acid Deposition Monitoring Program (Program 1) are to:

- Quantify the present levels of acidity and related chemical species in wet and dry deposition at regionally representative sites in Florida.
- Identify the spatial and temporal variability of these species over a three-year period.
- Provide a limited set of complementary data to the electric utility industry's UAPSP study (see Project EM12).
- Establish the accuracy, precision, and overall uncertainty of the data obtained.

Project Description:

During Phase I (January 1981 through September 1981), existing Florida data and literature were reviewed in order to determine the required number of sampling stations and to locate the samplers so as to utilize the existing data base effectively. It was decided that 14 sampling locations were needed to adequately characterize acid deposition within the state.

Actual monitoring activities began in mid-Phase I and will continue throughout Phases II, III and IV, should the program's direction not change. Each station is equipped with a wet/dry type collector, with wet samples collected and analyzed on a weekly basis. Dry samples are collected every two months. At four sites, two samples are collected to determine variability inherent in the equipment and location. At two of these four sites, one sample is collected on a daily basis and one on a weekly basis for comparing weekly versus daily data. At the two sites operating on the daily sample collection basis, hi-volume air samples (HI-VOLS) are operated for 24 hours every third day.

Rainfall, pH, and conductivity data are measured under temperature-controlled conditions by a trained and qualified field technician. Samples are then shipped to the laboratory for analysis. Conductivity, pH,  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{2+}$ , and  $\text{Ca}^{2+}$  concentrations are determined by standard methods. Personnel performing the analyses have been tested and certified for each analysis. All laboratory work is to be checked and verified by the Project Quality Assurance supervisor as outlined in the Quality

Assurance (QA) plan. Both the field and laboratory operations are subjected to regular QA audits.

Expected Output/Delivery Dates:

As previously stated, this project consists of four phases. Phase I of the Acid Deposition Monitoring Program started in January 1981 and was completed in September 1981, with a interim report published in January 1982. Subsequent phases and reports (as currently planned) are as follows:

Phase II	October 1981 - September 1982 Interim Report January 1983
Phase III	October 1982 - September 1983 Interim Report January 1984
Phase IV	October 1983 - March 1985 Final Report July 1985

Project Title

Florida Acid Deposition Study  
Impact Analysis of Alternate Emission Reduction Scenarios (Program  
4 of 4) (EM22)

Funding Organization:

Florida Electric Power Coordinating Group, Inc.  
402 Reo Street, Suite 214  
Tampa, FL 33609  
(813) 877-5301

Project Officer:

Charles D. Henderson  
Environmental Affairs Department  
Florida Power & Light Company  
P.O. Box 529100  
Miami, FL 33152  
(305) 552-4819

Research Organization and Principal Investigator:

E.R. Hendrickson  
Project Director  
Environmental Science & Engineering, Inc.  
P.O. Box ESE  
Gainesville, FL 32602  
(904) 372-3318

Period of Performance:

September 1981 through March 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$56,000	\$80,000*

Research Objectives:

The Florida Acid Deposition study's primary objective is to assess and develop information needed to place the acid deposition issue in proper perspective for Florida as to its magnitude, variability, sources, effects, and control options. The study is divided into four study programs (each program is described as a separate

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\*planned funding

project in this document - consult the Funding Organization Index) and four time phases, to allow periodic reassessment of the desirability of continuing funding or changing direction.

The specific objective of the Impact Analysis of Alternate Emission Reduction Scenarios Program is to evaluate the costs/benefits of possible regulatory control options aimed at reducing acidic deposition.

#### Project Description:

Beginning in Phase II (October 1981 through September 1982), this cost/benefit analysis may include an evaluation of these possible regulatory control options:

- Regional emission caps.
- Fuel cleaning.
- Retrofitting air pollution control equipment.
- Least emissions dispatching.

Hypothetical regulatory scenarios are to be developed by a subcommittee of the Florida Electric Power Coordinating Group and distributed to members for their review.

Analyses will be performed using data recognized by regulatory agencies or accurate information provided by Florida utilities, with standard accepted techniques for determining costs/benefits with used. Impacts on system reliability will also be evaluated. Data bases for this program will be the Source Attribution and Long-Range Transport Program (see Project AP17) and the Ecological and Material Effects Program (see Project EE26). Whenever possible, costs/benefits will be quantified, and where costs/benefits are not quantifiable, discussion of their probable magnitude and significance will be given. Calculations and discussion of both measurable and immeasurable costs/benefits will be presented in terms of persons, groups, or agencies accruing the cost/benefits. The analysis will include both short-term and long-term and/or reversible or irreversible costs/benefits. The environmental, social, and economic costs/benefits are to be aggregated for an estimate of the net overall costs/benefits.

#### Expected Output/Delivery Dates:

As previously stated, this project consists of four phases. Phase I started in January 1981 and ended in September 1981. The Impact Analysis of Alternate Emissions Reduction Scenarios Program began during Phase II (October 1981 through September 1982). Subsequent phases (as currently planned) are as follows:



Phase III    October 1982 - September 1983  
Phase IV    October 1983 - March 1985

Interim reports will be produced after the completion of each phase, with a final report expected in mid-1985.

Project Title:

Acidic Aerosol and Precipitation Field Experiment (EM23)

Funding Organization:

Ford Motor Company, Scientific Research Laboratory, Fuels and  
Lubricants Department

Project Officer:

William R. Pierson  
Scientific Research Laboratory, Room S-3044  
Ford Motor Company  
P.O. Box 2053  
Dearborn, MI 48121  
(313) 322-8072

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

January 1982 through December 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$150,000	\$250,000*

Research Objective:

The goal of this work is to develop a technique for monitoring gas phase, aerosol, and aqueous phase chemistry related to acidic deposition.

Project Description:

The project will consist of summer field experiments during 1982 and 1983:

- Summer 1982

A nine day field experiment was conducted atop Allegheny Mountain in Pennsylvania to develop and test techniques for monitoring chemical species in the atmosphere before, during and after precipitation events. Also, comparisons were made

\*planned funding

between the chemistry of rainfall, dewfall, and cloud (fog) water.

Aerosol species measured included:  $\text{H}^+$ ,  $\text{NH}_4^+$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ , and other various cations and anions. Gas-phase species measured included  $\text{HNO}_3$ ,  $\text{NH}_3$ , and  $\text{NO}_2$ . Aqueous species measured included  $\text{H}^+$ ,  $\text{NH}_4^+$ ,  $\text{SO}_4^{2-}$ , and  $\text{NO}_3^-$ . Other measurements taken were: optical scattering and absorption, visual range, temperature, humidity, barometric pressure, wind speed and direction, rainfall amount, and particle size distribution.

● Summer 1983

In 1983 a larger field study will investigate aerosol, gas phase, precipitation and cloud chemistry relationships, regarding:

- Sources of acidity.
- Chemical atmospheric transformations.
- The role of automotive emissions.

Simultaneous sampling will be performed atop two mountain ridges 26 miles apart on an east-west line.

Expected Output/Delivery Dates:

Major publications in the scientific literature are expected after the 1983 field experiment.

Project Title:

A Comparison of Surrogate Surfaces for Dry Deposition Collection  
(EM24)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Jean L. Muhlbaier  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3345

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

June 1981 through March 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$62,250*	\$62,250*	

Research Objective:

The reproducibility of dry deposition collection was researched using a variety of surrogate surfaces.

Project Description:

A study was initiated to test the collection efficiency of a variety of surrogate dry deposition surfaces:

- Polyethylene bucket.
- Water.
- Greased foil.
- Ungreased foil.

\*estimated funding

- Teflon filter.
- Quartz filter.
- Glass filter.
- Nylon filter.

The surfaces were exposed for one-week intervals and were protected from rainfall. After collection the surfaces were leached into distilled water and analyzed for pH,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , and  $\text{NH}_4^+$ .

The study addressed the following factors:

- The reproducibility between duplicate collectors.
- The reproducibility between different collectors.
- The effect of surface pH and roughness on collection.
- The importance of gaseous absorption.
- A comparison of upward and downward facing surfaces.

Output/Delivery Date:

A report will be available in September 1982.

Project Title:

Acid Precipitation in the Detroit Area (EM25)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Jean L. Muhlbaier  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3345

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

June 1981 through (undetermined)

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$125,000*	\$187,500*	undetermined

Research Objectives:

Precipitation and air quality at suburban and rural locations in southeastern Michigan is monitored in order to determine:

- The role of local sources on precipitation chemistry.
- The relative importance of wet and dry deposition.
- The effect of wind direction on precipitation concentrations.

Project Description:

Two precipitation monitoring stations were established, one in Warren, a suburban location, and the other in Lapeer, a rural location. Deposition is collected in Aerochem-Metric samplers, with wet deposition collected on an event basis and dry deposition on a weekly basis. Daily ambient particulate collections are also made at each site. Analyses of pH, acidity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,

\*estimated funding

$\text{NH}_4^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$  and  $\text{K}^+$  are made. In addition, measurements of  $\text{HNO}_3$ ,  $\text{NH}_3$  and particle size are made at the Warren site.

Expected Output/Delivery Dates:

An initial report has been produced detailing rain chemistry during the summer of 1981 as General Motors report GMR-4037. An additional report will be available in mid-1983.

Project Title:

Acid Snow and Acid Shock (EM26)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Steven H. Cadle  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3488

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

December 1981 through June 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$12,500*	\$62,250*	\$62,250**

Research Objectives:

The objectives of the project are:

- To determine the stability of ionic species in snowpack.
- To estimate the contribution of dry deposition to the ionic content of the snowpack.
- To determine the fate of selected chemical species, especially nitrate ( $\text{NO}_3^-$ ), during and after snowmelt.

Project Description:

A field program was conducted at the University of Michigan Biological Station near Pellston, Michigan during the 1981-82 winter. Wet and dry deposition were collected on a weekly basis. Snow cores were collected in triplicate on a weekly basis at two

\_\_\_\_\_  
\*estimated funding

\*\*estimated future funding



sites. The cores were sectioned to determine concentration profiles of the measured species  $H^+$ ,  $NH_4^+$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$ ,  $K^+$ ,  $Cl^-$ ,  $SO_4^{2-}$ ,  $NO_3^-$ , as well as specific conductance. In addition, weekly water samples were collected from the Little Pigeon River. The discharge rate of the river was determined at the time the samples were collected. Total deposition of all species was compared to the accumulated quantities of the species in the snowpack, in order to determine their stability. Concentration profiles were also used to determine changes in the snowpack. Monitoring of the snowpack and the Little Pigeon River during the melt period was conducted to determine how much nitrate and other species were flushed into the river. It is anticipated that further studies will be conducted during the 1982-83 winter.

Expected Output/Delivery Date:

The 1981-82 winter study report will be available late in 1982.

Project Title:

Nitric Acid ( $\text{HNO}_3$ ) Measurement Methods (EM27)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Steven H. Cadle  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3488

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

January 1981 through June 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$12,500*	\$31,250*	\$31,250**

Research Objectives:

The objectives of this project are to compare and validate current methods of measuring ambient nitric acid ( $\text{HNO}_3$ ) concentrations and to develop improved procedures.

Project Description:

In 1981-82 two field studies will be conducted. Each will last approximately 30 days and will entail the collection of 24 hour samples of  $\text{HNO}_3$  and  $\text{NO}_3^-$  by the nylon filter technique, the denuder difference method and the nylon denuder method.  $\text{SO}_4^{2-}$  will be measured on all filter samples and will be used for sampling and analysis quality control. Total aerosol acidity will also be determined. The results of this study will be used to determine future project direction, which is anticipated to include the study of alternate diffusion denuder techniques for the collection of  $\text{HNO}_3$ .

\*estimated funding

\*\*estimated future funding

Expected Output/Delivery Date:

A report describing the results of the 1981-82 field studies will be issued in late 1982.

Project Title:

Role of Hydrogen Peroxide ( $H_2O_2$ ) in Conversion of Sulfur Dioxide ( $SO_2$ ) to Acids (EM28)

Funding Organization:

General Motors Research Laboratories

Project Officer:

Peter J. Groblicki  
Environmental Science Department  
General Motors Research Laboratories  
Warren, MI 48090  
(313) 575-3367

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

January 1981 through September 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$25,000*	\$25,000*	\$25,000**

Research Objective:

The objective of this project is to assess the role of hydrogen peroxide ( $H_2O_2$ ) in producing acid by monitoring  $H_2O_2$  in precipitation and ambient air, and (possibly) in smog chamber atmospheric simulations.

Project Description:

In 1981 a  $H_2O_2$  monitor capable of continuous monitoring of atmospheric gaseous  $H_2O_2$  levels at 1.0 ppb or greater was constructed. The system is based on the luminal technique which has been described by Dr. Gregory Kok of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. Currently, the method is being studied with regard to potential interferences. The instrument will then be used to monitor ambient  $H_2O_2$  concentrations in the Warren, Michigan area and in wet deposition

\*estimated funding  
\*\*estimated future funding

simultaneously with the measurement of other species. It is expected that these results will provide a  $\text{H}_2\text{O}_2$  "climatology" for southeastern Michigan and information about the relationship between precursors and  $\text{H}_2\text{O}_2$ .

Expected Output/Delivery Date:

Data is expected to be available in late 1983.

Project Title:

National Atmospheric Deposition Program (NADP) Monitoring Station  
(EM29)

Funding Organization:

International Paper Company

Project Officer:

M.D. Aldridge  
International Paper Company  
Corporate Research Center  
P.O. Box 797  
Tuxedo Park, NY 10987  
(914) 351-2101

Research Organization and Principal Investigator:

Same as Project Officer

Period of Performance:

20 July 1980 through 20 July 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$12,750	\$11,350	\$11,350	\$11,350*

Research Objectives:

The objective of this project is to establish and maintain a wet/dry deposition monitoring station near Nacogdoches, Texas under the auspices of the National Atmospheric Deposition Program (NADP), a national network consisting of approximately 95 stations funded by government, educational, and private sector entities. Research objectives of the NADP are as follows:

- To establish an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited throughout the United States.

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\*planned funding

- To determine the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases in total atmospheric deposition throughout the United States.
- To develop optimum procedures for collecting precipitation and dry particulate matter.
- To determine the stability of certain constituents of precipitation during collection, transport, and storage prior to analysis.

Project Description:

The years 1981 and 1982 were used to: (1) select and prepare a suitable site (meeting NADP criteria for monitoring locations) at International Paper Company's Forest Seed Center near Nacogdoches, Texas; (2) purchase and install monitoring apparatus; (3) select and train a site technician; and (4) initiate sampling of wet/dry deposition on a routine basis. Aerochem Metrics 201 wet/dry deposition collectors are utilized to collect weekly wet deposition and bimonthly dry deposition. Samples are shipped to the Illinois State Water Survey in Champaign, Illinois, where they are analyzed for pH, conductivity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ .

Expected Output/Delivery Dates:

Quarterly NADP data reports are issued from the Natural Resource Ecology Laboratory at Colorado State University in Fort Collins, Colorado.

Project Title:

Syl Laskin Steam Electric Station Precipitation Monitoring Program  
(EM30)

Funding Organization:

Minnesota Power

Project Officer:

Scott E. Jasperson  
Environmental Affairs Department  
Minnesota Power  
30 West Superior Street  
Duluth, MN 55802  
(218) 722-2641

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

August 1982 through May 1985

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$30,000	\$40,700

Research Objectives:

The basic objectives of the program are:

- To provide quality precipitation chemistry data from northeastern Minnesota to the Minnesota Pollution Control Agency for a period of three years.
- To collect precipitation samples on an "event" basis.
- To operate and maintain the precipitation collection station according to acceptable quality assurance procedures.
- To maintain a high percentage of data capture over the three year monitoring period.

Project Description:

Wet and dry deposition samples will be collected at the Fernberg Road monitoring station located approximately twenty-two miles northeast of Ely, Minnesota, for a period of 3 years. Wet



deposition samples will be collected on an "event" basis and dry deposition samples will be allowed to accumulate for a period of two months using an Aerochem Metrics precipitation collector. pH and conductivity measurements will be taken in the field. The Minnesota Department of Health will perform analyses for the following constituents in both wet and dry deposition samples:

$\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Al}^{3+}$ , Pb, acidity, conductivity, volume, and pH.

Expected Output/Delivery Dates:

Results will be supplied to the Minnesota Pollution Control Agency as they are available.

Project Title:

Minnesota/Wisconsin Power Suppliers Group Atmospheric Deposition  
Monitoring Network (EM31)

Funding Organization:

Minnesota/Wisconsin Power Suppliers Group

Project Officer:

Steven P. Lindenberg  
Cooperative Power Association  
8020 Mitchell Road  
Eden Prairie, MN 55344  
(612) 937-8599

Research Organization and Principal Investigator:

Sagar V. Krupa  
Department of Plant Pathology  
University of Minnesota  
1519 Gortner Avenue  
St. Paul, MN 55108  
(612) 376-3871

Period of Performance:

15 April 1981 through (continuing)

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$44,000	\$120,000	undetermined

Research Objectives:

The objectives of this project are to investigate the phenomenon of atmospheric deposition in Minnesota by:

- Quantifying the chemical constituents in both the wet and dry phases that may be associated with atmospheric pollutant deposition.
- Relating deposition chemistry to atmospheric trajectory in order to identify transport mechanisms.

Project Description:

This summer sampling network consists of six sites distributed throughout Minnesota and one site in southwest Wisconsin. Each site is equipped with a refrigerated wet precipitation collector

designed by researchers at the University of Minnesota. Wet samples are collected sequentially on a sub-event (0.25 centimeters) basis from mid-April to the end of October. Samples are held at 4° C to be picked up within 48 hours of collection and transported for analysis to a central laboratory. Dry deposition is collected for 24 hours every sixth day, using virtual impaction dichotomous air samplers.

The following parameters are measured for wet precipitation:

pH,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{NH}_4^+$ ,  $\text{Br}^-$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{I}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$ , B, Cu, Fe, Mn, Ni, Pb, and Zn.

Dry deposition samples are analyzed for:

$\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{Br}^-$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{I}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Al}^{3+}$ , As, Ba, Fe, Hg, Mn, Pb, S, Si, V, and Zn.

Data is stored on a computer tape and analyzed using various statistical programs. Events of particular interest are compared to trajectory analysis of upper air movement produced from NOAA data.

Expected Output/Delivery Dates:

This project replaced and supplemented the Sherburne County Generating Plant Acid Deposition Study (see Project EM36) for the 1981 rainy season.

Annual reports are to be prepared by June of the year following data collection. Portions of the data will be available in monthly activity updates.

Project Title:

An Investigation of the Chemical Quality of Atmospheric  
Precipitation in Mississippi (EM32)

Funding Organizations:\*

Mississippi Power Company  
Mississippi Power and Light

Project Officer:

Gerald G. Parker, Jr.  
District Chief, U.S. Geological Survey  
100 West Capitol Street, Suite 710  
Jackson, MS 39269  
(601) 960-4600

Research Organization and Principal Investigators:

Gene Bednar  
Paul Grantham  
District Water Quality Specialist  
100 West Capitol Street, Suite 710  
Jackson, MS 39269  
(601) 960-4600

Period of Performance:

1 April 1982 through 30 September 1986

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$42,400**	undetermined
				(\$7,067)***	

Research Objectives:

This two-phase project has the following research objectives:

- To monitor precipitation chemistry for three to five years in order to determine the input of acid deposition related species.

\*non-private sector funding supplied by the U.S. Geological Survey and the Mississippi Bureau of Pollution Control

\*\*total project funding

\*\*\*Mississippi Power Company and Mississippi Power and Light combined funding

- To perform trend analyses of precipitation data and available long-term water-quality records from nearby streams.
- To design and implement a research project to investigate the potential effects of acid precipitation on stream biota, lakes, soils, forests, etc.

#### Project Description:

During Phase I, three wet-precipitation samplers, located in Lafayette, Perry, and Hancock counties, will be used to collect weekly wet deposition for 3 to 5 years. Samples will be analyzed for pH, conductivity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$ . Thus, a precipitation chemistry data base will be formed for Mississippi, including sites in Clinton and Meridian from other projects.

During Phase II, collected precipitation data will be analyzed for trends. In addition, long-term water quality for nearby streams will be analyzed. If Phase I monitoring indicates that atmospheric acidity is a potential problem, a research project(s) will be planned and undertaken to investigate acid deposition effects on aquatic and/or terrestrial ecosystems.

#### Expected Output/Delivery Dates:

During Phase I, annual summaries of weekly precipitation chemical analyses will be published in a U.S. Geological Survey Water Data Report entitled, "Water Resources Data for Mississippi; Water Year \_\_\_\_".

Project Title:

National Coal Association/Bituminous Coal Research Precipitation  
Quality Network (EM33)

Funding Organizations:

Management of the network is funded by National Coal Association.  
The operating costs of sample collection and analysis are provided  
by 35 cooperating organizations.

Project Officer:

Joseph E. Mullen  
Director, Environmental Affairs  
National Coal Association  
1130 17th Street, N.W.  
Washington, D.C. 20036  
(202) 463-2636

Principal Investigator:

Charles T. Ford, Group Manager  
Technical Support Services  
Bituminous Coal Research, Inc.  
350 Hochberg Road  
Monroeville, PA 15146  
(412) 327-1600

Period of Performance:

May 1980 through (undetermined)

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$150,000	\$400,000	\$500,000	undetermined

Research Objectives:

The overall goal of the Precipitation Quality Network (PQN) is to establish an independent data base that will provide first-hand information concerning precipitation quality in those geographic areas and regions covered by PQN monitoring stations. Specifically, these data will be used to:

- Characterize the chemical nature of precipitation, especially the relationship between acidity (pH) and chemical composition.
- Identify spatial and temporal variations in precipitation chemistry, including latitudinal/longitudinal variations and

long-term time trends in pH, by comparison with historical data from other networks.

- Where possible, examine relationships between precipitation acidity and specific meteorological phenomena.

Project Description:

The 45 network stations are located in 19 states extending from the Rocky Mountains to the Atlantic Ocean. The major concentration of stations are located in Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia.

Aerochem Metric 201 wet/dry samplers are being used to collect weekly wet samples. Event sampling is planned for limited periods. Sample analysis is being conducted by Bituminous Coal Research, Inc., for pH, conductivity, acidity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{Ca}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , and  $\text{Mg}^{2+}$ .

Expected Output/Delivery Dates:

Annual reports

Periodic data evaluation reports

Project Title:

Development of Forest Products Industry Participation in the  
National Atmospheric Deposition Program (NADP) Monitoring Network  
(EM34)

Funding Organization:

National Council of the Paper Industry for Air and Stream  
Improvement, Inc. (NCASI)

Project Officer:

Russell O. Blosser  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9001

Research Organization and Principal Investigator:

John E. Pinkerton  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9047

Period of Performance:

1 April 1981 through 31 March 1983.

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$3,000	\$2,000	

Research Objective:

The objective of this project is to ensure that long-term high quality deposition monitoring is conducted in important timber growing regions of the United States, so that the magnitude of and trends in the deposition of beneficial and harmful substances may be adequately determined.

Project Description:

Work will be undertaken to:

- Assemble information on deposition monitoring networks and assess the utility of deposition monitoring data to the forest products industry.



- Coordinate selection of additional National Atmospheric Deposition Program (NADP) monitoring sites (see Project EM37) in important timber growing regions with inadequate coverage.
- Promote establishment and operation of NADP monitoring stations by forest products companies in areas with inadequate coverage.
- Evaluate trends and geographic patterns in wet ionic deposition based on monitoring data.

Expected Output/Delivery Dates:

The following results are anticipated:

- Establishment and operation of NADP monitoring stations in all important timber growing regions of the U.S.
- Direct forest industry support for approximately 10 NADP stations in important timber growing regions by 1983.

Project Title:

Development of Sulfur Dioxide and Oxides of Nitrogen Emission  
Estimates from Forest Products Industry Manufacturing Facilities in  
1980 (EM35)

Funding Organization:

National Council of the Paper Industry for Air and Stream  
Improvement, Inc. (NCASI)

Project Officer:

Russell O. Blosser  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9001

Research Organization and Principal Investigator:

John E. Pinkerton  
NCASI  
260 Madison Avenue  
New York, NY 10016  
(212) 532-9047

Period of Performance:

1 October 1981 through 30 June 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$25,000	

Research Objective:

The objective of this project was to determine the quantity of sulfur dioxide (SO<sub>2</sub>) and oxides of nitrogen (NO<sub>x</sub>) emitted from forest products industry facilities during 1980 in different regions of the United States, while comparing these emissions to those from other industry and mobile sources.

Project Description:

The following tasks were undertaken:

- Data on fuel use, fuel sulfur content, process emissions, product production, etc., for forest products industry manufacturing facilities were assembled.

- SO<sub>2</sub> and NO<sub>x</sub> emissions for different regions were calculated.
- Forest product industry emission estimates were compared to those for other source types.

Output/Delivery Date:

A summary report was completed in June 1982.

Project Title:

NSP/Sherburne County Generating Plant Acidic Deposition Study  
(EM36)

Funding Organization:

Northern States Power Company

Project Officer:

Joseph L. Wolf  
Northern States Power Company  
414 Nicollet Mall  
Minneapolis, MN 55401  
(612) 330-5536

Research Organization and Principal Investigator:

Sagar V. Krupa  
University of Minnesota  
Department of Plant Pathology  
1519 Gortner Avenue  
St. Paul, MN 55108  
(612) 376-3871

Period of Performance:

April 1976 through October 1980  
April 1982 through (continuing)

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$240,000	\$40,000	--	\$10,000	undetermined

Research Objectives:

Specific objectives of this project include:

- Quantification of wet and dry deposition constituents, particularly those associated with coal and oil combustion.
- Comparisons of wet and dry deposition chemistry data from network sites with data from other Minnesota sites collected during the same year.
- Estimation of the contributions of local and out of state sources of sulfate and acidic deposition.
- Estimation of the magnitude to which acid deposition presents a genuine threat to Minnesota resources.

Project Description:

This summer sampling network consists of one or two monitoring sites in central Minnesota located near the Sherburne county power plant. Each site is equipped with a refrigerated wet precipitation collector designed by researchers at the University of Minnesota. Wet samples are collected sequentially on a sub-event (0.25 centimeters) basis from mid-April to the end of October. Samples are stored at 4°C, picked up within 48 hours of collection and transported for analysis to a central laboratory. Dry deposition is collected for 24 hours every sixth day using virtual impaction dichotomous air samplers.

The following parameters are measured for wet precipitation:

pH,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{NH}_4^+$ ,  $\text{Br}^-$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{I}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$ , B, Cu, Fe, Mn, Ni, Pb, and Zn.

Dry deposition samples are analyzed for:

$\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{Br}^-$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{I}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Al}^{3+}$ , As, Ba, Fe, Hg, Mn, Pb, S, Si, V, and Zn.

The data are stored on a computer tape and analyzed using various statistical programs. Events of particular interest are compared to trajectory analysis of upper air movement produced from NOAA data.

Expected Output/Delivery Date:

This project was temporarily replaced by the Minnesota/Wisconsin Power Suppliers Group Atmospheric Deposition Monitoring Network (see Project EM31) during the 1981 rain season.

Annual reports are to be prepared by June of the year following data collection. Portions of the data will be available in monthly activity updates.

Project Title:

National Atmospheric Deposition Program (NADP) Monitoring Stations  
(EM37)

Funding Organization:

Potlatch Corporation

Project Officer:

T.W. Kamps  
Potlatch Corporation  
Two Embarcadero Center, 20th Floor  
P.O. Box 7864  
San Francisco, CA 94120  
(415) 981-5980

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

June 1982 through (undetermined)\*

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$32,000	undetermined

Research Objectives:

The objective of this project is to establish and maintain wet/dry deposition monitoring stations at Headquarters, Idaho and Warren, Arkansas under the auspices of the National Atmospheric Deposition Program (NADP), a national network consisting of approximately 95 stations funded by government, educational and private sector entities. Research objectives of the NADP are as follows:

- To establish an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited throughout the United States.

\*Potlatch Corporation will continue this research effort for between 5 and 10 years.

- To determine the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases in total atmospheric deposition throughout the United States.
- To develop optimum procedures for collecting precipitation and dry particulate matter.
- To determine the stability of certain constituents of precipitation during pre-analysis collection, transport, and storage.

Project Description:

Aerochem Metrics 201 wet/dry deposition collectors are utilized to collect weekly wet deposition and bimonthly dry deposition. Samples are shipped to the Illinois State Water Survey in Champaign, Illinois, where they are analyzed for pH, conductivity,  $44_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ .

Output/Delivery Dates:

Quarterly NADP data reports are issued from the Natural Resource Ecology Laboratory at Colorado State University in Fort Collins, Colorado.

Project Title:

Wet/Dry Atmospheric Deposition/Suspension in the Southwestern  
United States (EM38)

Funding Organization:

Southern California Edison Company

Project Officer:

E.C. Ellis  
Research and Development  
Southern California Edison Company  
P.O. Box 800  
Rosemead, CA 91770  
(213) 572-1866

Research Organization and Principal Investigator:

R.J. Gordon  
Global Geochemistry Corporation  
6919 Eton Avenue  
Canoga Park, CA 91303  
(213) 992-4103

Period of Performance:

March 1979 through December 1987

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		not available			

Research Objective:

This project is being undertaken in order to quantify the nature and extent of acid deposition in the southwestern U.S., especially southern California.

Project Description:

Precipitation is collected at between 13 and 28 sites within a 80 km radius of Los Angeles, referred to as the South Coast Air Basin (SCAB), and at two sites in the east central California desert, referred to as the Southeast Desert Air Basin (SEDAB). Fog and mist are also occasionally collected at various locations. Samples are analyzed for pH, conductivity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ , Fe, Ni, Pb, and V. The monitoring results will be examined for trends in quantity and composition of atmospheric deposition.



Atmospheric deposition models will be developed and evaluated for the SCAB and SEDAB, with a goal of making these models applicable to other arid regions. Also, source apportionment techniques will be applied to the SCAB wet deposition data base, especially with relation to determining company contributions.

Expected Output/Delivery Dates:

Annual summary reports are submitted to the funding organization. Technical papers will be submitted to peer-reviewed journals.

Project Title:

Precipitation Quality in the Vicinity of TVA Coal-fired Power  
Plants (EM39)

Funding Organization:

Tennessee Valley Authority, Division of Energy Demonstrations and  
Technology

Project Officer:

John D. Brellenthin  
Tennessee Valley Authority  
Environmental Support Staff  
1110 Chestnut Street, Tower II  
Chattanooga, TN 37401  
(615) 751-5672

Research Organization and Principal Investigator:

William J. Parkhurst  
Tennessee Valley Authority  
Air Resources Program  
River Oaks Building  
Muscle Shoals, AL 35660  
(205) 386-2555

Period of Performance:

November 1978 through June 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
	\$23,000	\$25,000	\$27,000	\$30,000	\$43,000*

Research Objectives:

This project represents an important part of the Tennessee Valley Authority's (TVA) comprehensive acidic precipitation program, which includes studies concerning deposition monitoring, atmospheric chemistry, long-range transport, and terrestrial and aquatic effects. This project has the following objectives:

- To establish the localized impact of power plant emissions on atmospheric deposition.

\*planned funding

- To establish associations between gaseous and aerosol air quality measurements and deposition quality.
- To establish the spatial and temporal variability of atmospheric deposition, in conjunction with regional trend monitoring data.

Project Description:

Beginning in November 1978 with biweekly wet and dry sample collection at each of TVA's 12 coal-fired power plants, this monitoring program presently consists of biweekly wet and bimonthly dry sample collection with AEC-type wet/dry collectors at six TVA power plants. Each sample is analyzed for volume, pH, conductivity, weak acidity, strong acidity,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{NH}_4^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$ . Each sample is validated (based upon chemical relationships), stored on TVA's computer system, and periodically submitted for statistical analysis and reporting.

Expected Output/Delivery Dates:

Mid-study data analysis and report, entitled "Atmospheric Deposition in the Tennessee Valley: 1979-1980," published during June 1982  
 Data reports (calendar years 1979, 1980, and 1981), September 1982  
 Data report (calendar year 1982), June 1983  
 Data report (calendar year 1983), June 1984  
 Final report, June 1984

Project Title:

Examination of the Bases for Trend Interpretation of Historical  
Rain Chemistry in the Eastern United States (EM40)

Funding Organization:

Utility Air Regulatory Group - Committee on Acid Deposition

Project Officer:

Althea Mitchell  
Hunton & Williams  
1919 Pennsylvania Avenue, N.W.  
Washington, D.C. 20036  
(202) 223-8650

Research Organization and Principal Investigator:

D.A. Hansen  
Environmental Research & Technology, Inc.  
2625 Townsgate Road  
Westlake Village, CA 91361  
(805) 497-0821

Period of Performance:

July 1980 through November 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		-- not available --			

Research Objectives:

The goals of this project were to examine the quality of historical data on precipitation chemistry in the eastern U.S., as well as past interpretation of this data.

Project Description:

An examination of historical precipitation chemistry data was undertaken for the eastern United States regarding the consistency of sampling and chemical analysis methods used. This was done in order to quantify uncertainties and biases associated with:

- Sampling and analysis methods.
- Use of data from different times and locales.
- Failure to analyze for certain compounds.

- Failure of previous investigators to consider all available data.

Output/Delivery Dates:

The final report was published as ERT Document No. P-A097R in November, 1981. Also, an article entitled "Review of Questions Regarding Rain Acidity Data" by D.A. Hansen and G.M. Hidy has been accepted for publication in Atmospheric Environment (1982).

Project Title:

Monitoring of Precipitation Chemistry in the Vicinity of a Large  
Coal-Fired Power Plant (EM41)

Funding Organization:

Western Energy Supply and Transmission (WEST) Associates

Project Officer:

R.C. Williams  
Public Service Company of New Mexico  
Alvarado Square  
Albuquerque, NM 87158  
(505) 848-2009

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

June 1982 through September 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$25,000	\$10,000*

Research Objectives:

This project has the following objectives:

- To determine if there is a significant difference between measured precipitation chemistry from a cloud affected by a nearby power plant and one not affected by the plant.
- To determine if there is a relationship between cloud electrification and precipitation chemistry.

Project Description:

Precipitation collectors will be installed at two sites near (within 10 km) a coal-fired generating station. The collectors will be covered until the precipitation event begins. Samples will be collected on an event basis and sent to a commercial laboratory

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\*planned funding

for analysis of pH, ionic composition, and presence of fly ash. Rainfall rate, with a tipping bucket rain gauge, will also be recorded.

Simultaneously with collection of the precipitation from an event, the earth's point discharge current (corona current) will be measured on a strip chart. The point discharge current measurements indicate the electrical activity of the storm system.

The data will be collected for one year and statistical correlations between pH and the variables measured for each storm event will be examined.

Expected Output/Delivery Date:

Final report, September 1983

Project Title:

Wisconsin Acid Deposition Cooperative Research Program  
Deposition Monitoring Network (EM42)

Funding Organization:

Wisconsin Utilities Association

Project Officer:

John Flickinger  
Wisconsin Power & Light Company  
222 West Washington Avenue  
Madison, WI 53701  
(608) 252-3084

Research Organization and Principal Investigator:

Abdul Alkezweeny  
Atmospheric Sciences Department  
Battelle Pacific Northwest Laboratories  
P.O. Box 999  
Richland, WA 99352  
(509) 375-3897

Period of Performance:

March 1982 through June 1984

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$90,000	\$125,000*

Research Objectives:

The Wisconsin Acid Deposition Cooperative Research Program includes four study programs (each program is described as a separate project in this document - consult the Funding Organization Index), with the following overall objectives:

- To identify sources and levels of acid deposition in Wisconsin.
- To quantify susceptible resources and the possible environmental effects of acid deposition.

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\*planned funds



- To identify and quantify the potential of current control and mitigatory technologies for reducing the potentially adverse effects of acid deposition.

The specific research objectives of the Deposition Monitoring Network include measurements of precipitation volume and chemistry at three sites in Wisconsin in order to:

- Provide data for future trend analyses.
- Provide event-related precipitation chemistry measurements for use in a trajectory analyses project (see Project AP27).
- Provide data for a study of two watersheds (see Project EE25).

#### Project Description:

The network consists of three sites: one each in northwest, central, and southeast Wisconsin. Precipitation is measured with a Belfort continuously-recording rain gauge, backed up by a standard National Weather Service rain gauge which is read daily. Precipitation is collected daily at all three sites and dryfall bi-weekly at the northwest site. Both wet and dry samples are collected using an Aerochem Metrics 301 sampler. pH and conductivity are measured at the site and the remainder of the sample is shipped to Battelle Pacific Northwest Laboratories for analyses. Both wet and dry samples are analyzed for the following constituents: pH, conductivity, total acidity (10% of samples only), strong acidity,  $S^{+4}$  (precipitation samples only),  $SO_4^{2-}$ ,  $NO_3^-$ ,  $NH_4^+$ ,  $Cl^-$ ,  $Na^+$ ,  $K^+$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Al^{3+}$ ,  $PO_4^{3-}$ , and total alkalinity.

#### Expected Output/Delivery Dates:

A report will be issued in mid-May 1983 documenting the first year's collection. A final report will be due on 1 June 1984.

Project Title:

Wisconsin Acid Deposition Cooperative Research Program  
Emission Source Inventory Program (EM43)

Funding Organization:

Wisconsin Utilities Association

Project Officer:

Paul Koziar  
Bureau of Air Management  
Wisconsin Department of Natural Resources  
P.O. Box 7921  
Madison, WI 53707  
(608) 266-7790

Research Organization and Principal Investigator:

same as Project Officer

Period of Performance:

February 1982 through 1 July 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$13,333	\$6,667**
				(\$9,667)*	(\$4,833)*,**

Research Objectives:

The Wisconsin Acid Deposition Cooperative Research Program includes four study programs (each program is described as a separate project in this document - consult the Funding Organization Index), with the following overall objectives:

- To identify sources and levels of acid deposition in Wisconsin.
- To quantify susceptible resources and possible environmental effects of acid deposition.

\*funds related to acid deposition

\*\*planned funding

- To identify and quantify the potential of current control and mitigatory technologies for reducing the potential adverse effects of acid deposition.

The specific research objectives of the Emissions Source Inventory Program are:

- To develop a comprehensive inventory of sulfur oxides ( $\text{SO}_x$ ) and nitrogen oxides ( $\text{NO}_x$ ) sources inside Wisconsin for base year 1980 and projection year 1990.
- To develop an inventory of  $\text{SO}_x$  and  $\text{NO}_x$  sources outside Wisconsin which may contribute to acid deposition in Wisconsin for use in atmospheric trajectory studies (see Project AP27).

#### Project Description:

The project will be composed of the following tasks:

- Task 1. Assemble a complete 1980  $\text{SO}_x$  and  $\text{NO}_x$  emissions data base for point, line, and area sources inside Wisconsin. Emissions data are being gathered by Bureau of Air Management staff from the Wisconsin Department of Natural Resources (DNR) files, regional planning commissions, and the U.S. Environmental Protection Agency (EPA). The area and line source emissions data will be compiled by season for each county. Point source emissions will be segregated by season, source type, fuel type, and process. A questionnaire will be sent to facilities producing major  $\text{SO}_x$  and  $\text{NO}_x$  point sources to gather more detailed emissions and fuel data.
- Task 2. Assemble a complete 1980  $\text{SO}_x$  and  $\text{NO}_x$  emissions data base for point, line, and area sources outside Wisconsin. Point source  $\text{SO}_x$  and  $\text{NO}_x$  emissions will be obtained from Minnesota, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Arkansas, and the Canadian provinces of Manitoba, Ontario, and Quebec. Area and line source emissions for those states and provinces will be obtained from the U.S. EPA and Environment Canada. The emission data will be used to extend the Sulfate Regional Experiment (SURE) emissions data base (see Project EM18) westward to provide an inventory for use in the Trajectory Analysis Research Program (see Project AP27).
- Task 3. Compile a 1980 inventory of  $\text{SO}_x$  and  $\text{NO}_x$  emissions from natural sources inside and outside Wisconsin. A literature survey will be conducted by Bureau of Air Management staff to determine emission rates for natural sources. Data on the extent and location of natural sources inside and outside Wisconsin will be used along with the

emission rates to compile an inventory of natural source emissions.

- Task 4. Project the 1980 emissions data to 1990. The 1980 SO<sub>x</sub> and NO<sub>x</sub> emissions will be projected to 1990 using growth factors developed from population and employment projections, coal use projections, utility advanced plans, and other growth indicators.

Expected Output/Delivery Date:

A report containing the 1980 and 1990 emission inventory data is due in July 1983.

**SECTION 4**

**OTHER PROJECTS (OP)**

Project Title:

A Review of the Phase II Interim Working Paper of the Impact Assessment Work Group, U.S./Canada Memorandum of Intent on Transboundary Air Pollution (OP1)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigator:

A. G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

January 1982 through February 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$26,000	

Research Objective:

The purpose of this project was to review the technical content of the Phase II report on the physical and biological consequences related to "transboundary air pollutants," specifically acid precipitation, prepared by the U.S./Canada Impact Assessment Work Group.

Project Description:

Attention was concentrated on reviewing material in Section 3 (Aquatic Impacts) and Section 4 (Terrestrial Effects), with some additional commentary provided on the health portion of Section 5 and regarding assumptions based on aquatic resources in Section 7. This review was made for the purpose of assisting in the improvement of the balance and scope of the working paper.

Output/Delivery Date:

The review was submitted to U.S./Canadian Working Group on behalf of API during February 1982.

Project Title:

Comments on the U.S. Department of Energy's (DOE) "Acid Rain Information Book" (DOE/EV/10273-1) (OP2)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigator:

A.G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

December 1980 through January 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$7,000		

Research Objective:

The objective of this study was to review and comment upon the technical content of the draft "Acid Rain Information Book" prepared for the U.S. Department of Energy (DOE) and later issued as DOE/EV/10273-1.

Project Description:

Commentary was prepared on material contained within the Executive Summary and Chapters 1-5. Principal issues critiqued included:

- Natural NO<sub>x</sub> and SO<sub>x</sub> emissions estimates and the pH of "unpolluted" precipitation.
- Atmospheric transport and scavenging processes.



- Effects of acidification from both natural and anthropogenic sources upon aquatic organisms, particularly fish.
- Lack of sufficient research data to document damage to terrestrial ecosystems from acid precipitation.
- Mitigation strategies.

Output/Delivery Date:

A summary of commentary was submitted to the Regulatory Analysis Division of the U.S. DOE on behalf of API during February 1981.

Project Title:

Comments on the U.S. Environmental Protection Agency (EPA) document  
"Air Quality Criteria for Oxides of Nitrogen" (External Review  
Draft, June 1980) (OP3)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will M. Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigator:

A.G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

October 1980 through November 1980

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$10,000			

Research Objective:

The objective of this project was to prepare commentary on the revised draft of the report by the Environmental Protection Agency entitled "Air Quality Criteria for Oxides of Nitrogen" (External Review Draft, June 1980).

Project Description:

Based upon an extensive literature review, the following issues were critiqued:

- The adequacy of the U.S. acid precipitation data base for documenting trends.
- Natural contributions to the acidity of precipitation.

- Effects of acidification upon soils, streams, forests, water quality, and aquatic biota.
- The role of forest fires in ameliorating acidification.
- Aluminum toxicity to aquatic biota.
- Mitigation techniques.

Output/Delivery Date:

Commentary was issued to EPA during November 1980.

Project Title:

Comments on the U.S. Environmental Protection Agency (EPA) document  
"Air Quality Criteria for Particulate Matter and Sulfur Oxides"  
With Relation to Acidic Precipitation (External Review Draft No. 1,  
April 1980) (OP4)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will M. Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigator:

A.G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

February 1980 through July 1980

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$30,000			

Research Objective:

The object of this project was to produce a commentary on the technical content of the draft report by the U.S. Environmental Protection Agency (EPA) entitled "Air Quality Criteria for Particulate Matter and Sulfur Oxides," particularly sections addressing acidic precipitation.

Project Description:

Significant issues and problems facing EPA in its attempt to deal with the phenomena of acidic precipitation were addressed, including:

- Uncertainties in reported sulfate levels due to changing analytical techniques.

- The importance of natural volcanic and biogenic sulfur sources to the observed sulfate levels in precipitation.
- Speculation concerning the ecological effects of acidic precipitation.
- Deficiencies in estimation techniques used by some investigators to construct pH isopleth maps.
- Inadequate analysis of the U.S. Geological Survey's Water Quality of Precipitation Network data base.

Output/Delivery Date:

Final commentary was issued to EPA on behalf of API during July 1980.

Project Title:

Reevaluation of Data Used to Assess Effects of Acidic Precipitation  
Upon Fish Stocks in Pennsylvania Streams (OP5)

Funding Organization:

American Petroleum Institute (API)

Project Officer:

Will M. Ollison  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-7375

Research Organization and Principal Investigators:

W.C. Retzsch  
A.G. Everett  
Everett & Associates  
416 Hungerford Drive, Suite 300  
Rockville, MD 20850  
(301) 279-2606

Period of Performance:

August 1980 through November 1980

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$5,000			

Research Objective:

The purpose of this study was to critique the EPA report "Probable Effects of Acid Precipitation on Pennsylvania Streams" (EPA 600/3-80-012) by Arnold et al. (1980).

Project Description:

Arnold et al. (1980) attempted to document the adverse effect of acidic precipitation upon fish stocks in Pennsylvania streams. In this study the data were reanalyzed for any correlations between changes in stream pH and test stocks.

Output/Delivery Date:

A final report was issued in November 1980.

Project Title:

Inventory of Acid Deposition Research Funded by the Private Sector  
(OP6)

Funding Organizations:

This project was equally co-funded by the American Petroleum Institute (API), the Edison Electric Institute (EEI), the Electric Power Research Institute (EPRI), and the Gas Research Institute (GRI).

Project Officer:

Jimmie Nelson  
Environmental Affairs Division  
American Petroleum Institute  
2101 L Street, N.W.  
Washington, D.C. 20037  
(202) 457-6381

Research Organization and Principal Investigator:

Joe Wisniewski  
Manager, Acid Rain Studies  
General Research Corporation  
7655 Old Springhouse Road  
McLean, VA 22102  
(703) 893-5900

Period of Performance:

15 January 1982 through 30 September 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$46,000	

Research Objectives:

The objectives of this project were to survey and document acid deposition-related research by the private sector for the purposes of:

- Updating research descriptions.
- Publicizing research.
- Encouraging scientific exchange.

Project Description:

Initial queries were made by telephone to contacts supplied by API, EEI, EPRI, and GRI, as well as individuals known to GRC. Questionnaires were sent to appropriate individuals. For each project identified, the following items were researched:

- Project title.
- Funding organization.
- Project officer.
- Research organization and principal investigator.
- Period of performance.
- Funding.
- Research objectives.
- Project description.
- Expected output/delivery dates.

Output/Delivery Date:

A report entitled "Inventory of Acid Deposition Research Funded by the Private Sector" was submitted to API during November 1982.



Project Title:

Acid Deposition Work Plan for the State of Texas (OP7)

Funding Organizations:\*

Brazos Electric Power Cooperative, Inc., Central Power & Light Company, City Public Service, Dallas Power & Light Company, Houston Lighting & Power Company, Lower Colorado River Authority, Southwestern Public Service Company, Texas Municipal Power Agency, Texas Power & Light Company, and West Texas Utilities

Project Officer:

C.D. Rao  
Texas Energy & Natural Resources Advisory Council  
Suite 505  
200 East 18th Street  
Austin, TX 78701  
(512) 475-0236

Research Organization and Principal Investigator:

Julian A. Levy, Jr.  
Project Manager  
Espey, Huston & Associates, Inc.  
P.O. Box 519  
Austin, TX 78767  
(512) 327-6840

Period of Performance:

April 1981 through January 1982

<u>Funding:*</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$6,750	\$4,500	

Research Objectives:

Primary objectives of the project were:

- To qualitatively evaluate the probable severity of an acid deposition problem (if any) in Texas and to place it into its proper perspective relative to other areas of the country.

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\*non-private sector funds also supplied by the Texas Energy & Natural Resources Advisory Council

- To evaluate critical aspects of the acid deposition question as they relate specifically to Texas.
- To formulate a plan of specific, prioritized tasks which must be accomplished in order to resolve critical issues and to quantify the magnitude of any possible acid deposition problem.

#### Project Description:

The first step in developing the work plan was to conduct an extensive search of the existing literature, related to the possible sources of acid deposition, the status of monitoring efforts, and the possible effects on vegetation, soils, surface waters, materials, and human health. Experts in each discipline determined which important questions remained to be answered. Key researchers were interviewed for the dual purposes of obtaining the most up-to-date information concerning acid deposition and of obtaining answers (if they existed) to important questions generated by the literature review. The results of the literature review and the investigator interviews were applied to the situation in Texas insofar as possible. This extrapolation of research conducted in other geographic areas to the Texas environment was based primarily on the experience of each team member with regard to their discipline in Texas.

The conclusions for each discipline were synthesized into a single coordinated plan. This effort consisted of prioritizing individual recommendations, developing a brief summary of the rationale for each recommendation, and describing the scope of work needed to accomplish each of the recommended tasks. Supporting documentation was compiled into a comprehensive technical summary.

#### Output/Delivery Date:

Two documents, Volume I: Plan to Evaluate Acid Deposition Issues in the State of Texas, and Volume II: Acid Deposition in Texas: Technical Summary and Perspective, were completed in January 1982.

Project Title:

International Pollution and National Laws: A New Approach (OPB)

Funding Organization:

Donner Foundation

Project Officer:

Phillip Jessup  
Donner Foundation  
630 5th Avenue  
New York City, NY 10020  
(212) 765-1695

Research Organization and Principal Investigator:

Gregory Wetstone  
Environmental Law Institute  
1346 Connecticut Avenue, N.W. #600  
Washington, D.C. 20036  
(202) 452-9600

Period of Performance:

May 1982 through June 1983

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		not available			

Research Objective:

The objective of this project is to develop an institutional approach to make the pollution control regimes in the U.S. and Canada more responsive to transboundary environmental concerns.

Project Description:

This work will explore in detail the practical feasibility of a new approach to the control of U.S./Canada transboundary pollution, as identified in a recent Environmental Law Institute study for the Office of Technology Assessment, U.S. Congress. The new mechanisms would amend the pollution control laws of both nations to authorize an independent, bilateral scientific committee to serve as the crucial link in applying general principles of international environmental responsibility to specific transboundary pollution problems. Domestic law in both nations would serve to implement responses to international pollution problems recommended by this committee.

Expected Output/Delivery Date:

A final report will be completed by the summer of 1983.

Project Title:

Acid Rain Consumer Brochure (OP9)

Funding Organization:

Duquesne Light Company

Project Officer:

Steve L. Pernick Jr.  
Duquesne Light Company  
435 Sixth Avenue  
Pittsburgh, PA 15219  
(412) 456-6178

Research Organization and Principal Investigator:

Gene Hunt  
28 Shannopin Drive  
Pittsburgh, PA 15202  
(412) 761-5355

Period of Performance:

January 1981 through August 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$5,000		

Research Objective:

The objective of this project was to provide a vehicle for informing the public in layman's terms about the knowns and unknowns of the acid precipitation issue.

Project Description:

The project involved a review of existing acid precipitation-related literature in order to answer the basic questions being asked by the general public, the news media, and lawmakers. The project was divided into two phases:

- Phase 1. Literature review followed by submission of draft questions and answers to Duquesne Light Company.
- Phase 2. Submission of draft questions and answers to other utilities and the Edison Electric Institute (EEI) for comment, followed by preparation of the final report.

Output/Delivery Date:

A 19-page brochure, entitled "What is Known About Acid Rain? What Should You Know About It?", was made available for distribution in August 1981.

Project Title:

Acid Deposition Decision Framework (OP10)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Richard Richels  
Energy Analysis and Environment Division  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2602

Research Organization and Principal Investigator:

D. Warner North  
Decision Focus, Inc.  
5 Palo Alto Square, Suite 410  
Palo Alto, CA 94303  
(415) 960-3454

Period of Performance:

12 August 1981 through 31 December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$120,000	\$130,000	\$10,000*

Research Objective:

The principal objective of this project is to develop, test, and transfer a workable framework for cost/benefit analysis of acid deposition control and mitigation strategies.

Project Description:

The following specific tasks will be undertaken:

- Task 1. Develop Work Plan. The project will begin with a series of meetings between the contractor, EPRI staff, and industry representatives to develop a refined definition of the scope of the analysis, a work plan, and a plan for

\*planned funding

utilizing relevant data, existing analytical models, and available sources of technical expertise.

- Task 2. Develop Initial Integration Framework. The product of this task will be an analytical framework considering the relevant components, noting the uncertainties in each. This includes an inventory of emissions related to acid deposition; evaluation of models for transport and chemical transformation; prediction of acid deposition incidence levels; estimates of acid deposition effects on aquatic life, vegetation, and materials; evaluation of acid deposition-induced damage; and estimation of costs of control or mitigation strategies.
- Task 3. Refine Integrating Framework and Preliminary Analysis. The initial integrating framework analysis will be refined and implemented in convenient computational form as determined to be appropriate in Task 2.
- Task 4. Collect Data Including Assessment of Probabilities. The contractor will collect data as the analysis is refined. In areas where data is lacking, the contractor will assess judgmental probabilities from technical experts to characterize the existing state of information regarding factors that are critical to industry and regulatory decisions regarding acid deposition.
- Task 5. Assess Decision Alternatives and Calculate Value of Resolving Uncertainty. The analysis will test the decision framework using a nominal set of judgmental probabilities and demonstrate how it can be used to: identify the best decision alternatives under uncertainty, investigate the sensitivity of results to changes in key inputs, and to carry out appropriate value of information calculations to determine the value of resolving uncertainty as a guide to future research on acid deposition.
- Task 6. Final Report, Computer Program, and Documentation. The research emphasis decision tree developed will be used to examine alternative research and development strategies, defined in terms of budget level and relative emphasis on various scientific areas, such as aquatic damage, damage to vegetation, and atmospheric transport and chemical conversion.

Expected Output/Delivery Date:

A final report is due on 31 December 1982.



Project Title:

Precipitation Chemistry Research Priorities (OP11)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

Peter K. Mueller  
Environmental Physics and Chemistry Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2586

Research Organization and Principal Investigator:

Volker Mohnen, Director  
Atmospheric Sciences Research Center  
State University of New York  
P.O. Box 9  
Albany, NY 12201  
(518) 457-4604

Period of Performance:

1 May 1982 through 31 December 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
				\$51,000	

Research Objective:

This contract is a portion of EPRI's Regional Air Quality Studies (RAQS) project. Under RAQS, visibility, dry deposition, cloud chemistry, precipitation chemistry, source emissions inventories, and atmospheric transport studies are being conducted. Regional air quality modeling capability is an ultimate goal.

The objective of this contract is to conduct a workshop of scientific experts on the atmospheric processes which govern the chemical composition of precipitation.

Project Description:

The workshop, to be conducted in late 1982 or early 1983, will deal with:

- Interrelated problems requiring research in scientifically tractable terms.
- Identification of information needs in cloud and precipitation chemistry so that scientists in specific fields of expertise are aware of and can contribute to each other's activities.
- Promoting increased coordination among diverse research communities.

Expected Output/Delivery Date:

A report will be available within six months of the workshop date.

Project Title:

Response of Agricultural Soils to Acid Precipitation (OP12)

Funding Organization:

Electric Power Research Institute (EPRI)

Project Officer:

John Huckabee  
Ecological Studies Program  
Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, CA 94303  
(415) 855-2589

Research Organization and Principal Investigator:

Peter VanVoris  
Battelle Columbus Laboratories  
505 King Avenue  
Columbus, OH 43201  
(614) 424-6424

Period of Performance:

1 January 1981 through 30 November 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			\$70,000		

Research Objective:

The objective of this project was to design a generic research approach to highlight and address possible problems associated with acid deposition to agricultural soils.

Project Description:

A thorough review of available scientific literature was performed to summarize research and results pertaining to the effects of acid deposition on the nutrient cycling of agricultural soils in the continental United States. Also, a workshop was planned and subsequently held in Columbus, Ohio during 12-13 May 1981 with 40 individuals present. The purpose of the workshop was to assemble representatives of industry, government, and academia to objectively evaluate the potential beneficial and harmful impacts of atmospheric acid deposition on agricultural soils; and to identify those issues requiring further research.

Output/Delivery Date:

A final report entitled "Response of Agricultural Soils to Acid Deposition" was published in July 1982 as Electric Power Research Institute (EPRI) Report EA-2508.

Project Title:

Advocacy Work on Acid Precipitation Issues (OP13)

Funding Organization:

Ford Foundation

Project Officer:

Ford Foundation  
320 East 43rd Street  
New York, NY 10017  
(212) 573-5000

Research Organization and Principal Investigator:

Clif Curtis  
Center for Law and Social Policy  
1751 N Street, N.W.  
Washington, D.C. 20036  
(202) 872-0670

Period of Performance:

September 1980 through June 1981

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		\$6,000	\$9,000		

Research Objective:

The objective of this project was to review and analyze the legal and policy implications of domestic law and international agreements regarding the United States/Canada transboundary acid precipitation issue.

Project Description:

Articles from domestic law and international agreements were analyzed, including:

- The 1909 U.S./Canada Boundary Waters Treaty.
- The U.S. Clean Air Act Amendments of 1970.
- The August 1980 U.S./Canada Memorandum of Intent on Transboundary Air Pollution.

Output/Delivery Dates:

Policy letters were sent to the U.S. Environmental Protection Agency and the U.S. Department of State. Testimony was provided at a Congressional hearing on acid precipitation.

Project Title

Acid Deposition in Europe and North America: National Responses to  
an International Problem (OP14)

Funding Organization:

German Marshall Fund of the United States

Project Officer:

Marianne Ginsberg  
German Marshall Fund of the United States  
11 DuPort Circle  
Washington, D.C. 20036  
(202) 797-6430

Research Organization and Principal Investigators:

Gregory Wetstone  
Armin Rosencranz  
Environmental Law Institute  
1346 Connecticut Avenue, N.W. #600  
Washington, D.C. 20036  
(202) 452-9600

Period of Performance:

September 1979 through July 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
		not available			

Research Objective:

The purpose of this work was to describe and assess how nations are  
dealing with the acid deposition phenomena and how national and  
international laws and policies might ultimately respond.

Project Description:

The work consisted of a review of:

- The range of scientific issues crucial to acid deposition and  
its impacts.
- The technologies available to industrialized nations to  
control pollutants causing acid deposition.

- A survey of the laws and policies relevant to the production and control of acid pollution in each of six European and North American nations chosen for detailed study.
- An analysis of the international laws and institutions available or potentially available to promote coordinated national action to control transboundary acid pollution.
- Conclusions and recommendations for improving the control of acid deposition and similar international pollution problems.

Expected Output/Delivery Date:

The report, now in draft form, will be completed in fall 1982 and ultimately published as a book.



Project Title:

A Review and Critique of the U.S./Canada Work Group 2 Phase II  
Modeling Activities (OP15)

Funding Organization:

Utility Air Regulatory Group - Atmospheric Modeling Committee

Project Officer:

Althea Mitchell  
Hunton & Williams  
1919 Pennsylvania Avenue, N.W.  
Washington, D.C. 20036  
(202) 223-8650

Research Organization and Principal Investigator:

C.S. Burton  
Systems Applications, Inc.  
101 Lucas Valley Road  
San Rafael, CA 94903  
(415) 472-4011

Period of Performance:

June 1981 through January 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			--not available --		

Research Objective:

The objective of this project was to review and critique the Phase II atmospheric modeling reports of Work Group 2 of the U.S./Canada Transboundary air pollution team.

Project Description:

The following reports were addressed:

- "Modeling Subgroup Report."
- "Atmospheric Sciences Review."
- "Phase II Working Report."
- "Transfer Matrices of the Phase I Report on Atmospheric Modeling."

- (12) Model Profiles for eight long-term, long-range transport (LRT) models.

Output/Delivery Date:

Final report (SAI no. 82017) published 15 January 1982.

Project Title:

The Effects of Acid Precipitation on Terrestrial and Aquatic  
Ecosystems (OP16)

Funding Organization:

The Utility Air Regulatory Group - Committee on Acid Deposition

Project Officer:

Althea Mitchell  
Hunton & Williams  
1919 Pennsylvania Avenue, N.W.  
Washington, D.C. 20036  
(202) 223-8650

Research Organization and Principal Investigator:

Allen S. Lefohn  
ASL & Associates  
111 North Last Chance Gulch  
Helena, MT 59601  
(406) 443-3389

Period of Performance:

June 1981 through February 1982

<u>Funding:</u>	<u>pre-1980</u>	<u>FY1980</u>	<u>FY1981</u>	<u>FY1982</u>	<u>post-1982</u>
			- not available --		

Research Objective:

The aim of this project was to evaluate the Phase II impact  
assessment report by the Work Group 1 (Impact Assessment Working  
Group) of the U.S./Canada Transboundary Team.

Project Description:

The document was reviewed with respect to the effects of acid  
precipitation on water bodies and vegetation. Also, proposed  
trends in precipitation acidity and the concept of the equilibrium  
pH of 5.6 were assessed.

Output/Delivery Date:

A final report was completed in February 1982.

APPENDIX A

CROSS - REFERENCED SUBJECT INDEX

## APPENDIX A. CROSS REFERENCED SUBJECT INDEX

### Atmospheric Processes (AP)

Following is a list of all projects related to each of five subcategories of the Atmospheric Processes (AP) research category.

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Physical/chemical transformation processes	AP5	1-9
	AP8	1-17
	AP9	1-20
	AP10	1-23
	AP12	1-28
	AP14	1-33
	AP15	1-36
	AP16	1-38
	AP19	1-45
	AP25	1-56
	EM6	3-11
	OP11	4-20
Wet deposition processes/modeling	AP7	1-13
	AP8	1-17
	AP21	1-48
	EE3	2-5
	EM38	3-79
	OP2	4-3
Dry deposition processes/modeling	AP7	1-13
	AP11	1-26
	AP13	1-30
	EE3	2-5
	OP2	4-3
Atmospheric transport modeling	AP1	1-1
	AP2	1-3
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	AP6	1-11
	AP15	1-36
	AP17	1-40
	AP20	1-47
	AP22	1-50
	AP23	1-52
	AP24	1-54
	AP26	1-58
	AP27	1-60
	EE3	2-5
	EM3	3-5
	EM13	3-26
	EM36	3-75
	OP2	4-3
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APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

Atmospheric Processes (AP) (concluded)

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Source apportionment	AP1	1-1
	AP3	1-5
	AP6	1-11
	AP15	1-36
	AP17	1-40
	AP27	1-60
	EM38	3-79

# APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

## Environmental Effects (EE)

Following is a list of all projects related to each of eight subcategories of the Environmental Effects (EE) research category.

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Agricultural crops	AP17	1-40
	AP27	1-60
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	EE16	2-32
	EE17	2-35
	EE24	2-57
	EE26	2-63
	EE30	2-71
	EM21	3-43
	OP1	4-1
	OP4	4-7
	OP5	4-9
	OP7	4-12
	OP16	4-30
Forest vegetation	AP17	1-40
	AP27	1-60
	EE2	2-3
	EE3	2-5
	EE6	2-11
	EE15	2-29
	EE19	2-42
	EE21	2-48
	EE22	2-51
	EE24	2-57
	EE25	2-59
	EE26	2-63
	EE28	2-67
	EE31	2-72
	EE34	2-78
	EM21	3-43
	EM42	3-87
	OP4	4-7
	OP7	4-12
	OP16	4-30
Soils	AP17	1-40
	AP27	1-60
	EE1	2-1
	EE2	2-3

# APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

## Environmental Effects (EE) (continued)

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Soils	EE3	2-5
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	EE13	2-25
	EE15	2-29
	EE17	2-35
	EE19	2-42
	EE21	2-48
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	EE25	2-59
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	EE29	2-69
	EE30	2-71
	EE31	2-72
	EE33	2-76
	EE35	2-80
	EM21	2-43
	EM42	2-87
	OP1	4-1
	OP3	4-5
	OP4	4-7
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	OP7	4-12
	OP12	4-22
	OP16	4-30
Aquatic systems - chemical and physical water properties	AP17	1-40
	AP27	1-60
	EE3	2-5
	EE4	2-7
	EE5	2-9
	EE6	2-11
	EE7	2-13
	EE8	2-15
	EE9	2-17
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	EE12	2-23
	EE14	2-27
	EE19	2-42
	EE22	2-51
	EE23	2-55
	EE25	2-59
	EE26	2-66
	EE27	2-67
	EE32	2-74



APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

Environmental Effects (EE) (continued)

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Aquatic systems - fauna/flora	EE33	2-76
	EE34	2-78
	EE35	2-80
	EE36	2-82
	EE38	2-86
	EM2	3-3
	EM21	3-43
	EM42	3-87
	OP1	4-1
	OP3	4-5
	OP4	4-7
	OP7	4-12
	OP16	4-30
	AP17	1-40
	EE3	2-5
	EE5	2-9
	EE6	2-11
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	EE9	2-17
	EE10	2-19
	EE11	2-21
	EE23	2-55
	EE26	2-63
	EE27	2-66
	EE30	2-71
	EE32	2-74
	EE35	2-80
	EE36	2-82
	EM2	3-3
	EM21	3-43
	OP1	4-1
	OP2	4-3
	OP3	4-5
	OP4	4-7
	OP5	4-9
	OP7	4-12
	OP16	4-30
Materials	EE3	2-5
	EE20	2-46
	EE26	2-63
	EE30	2-71
	EE37	2-84
	OP7	4-12

APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

Environmental Effects (EE) (concluded)

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Liming/mitigatory techniques	EE5	2-9
	EE11	2-21
	EE14	2-27
Ecosystem modeling	AP27	1-60
	EE18	2-39
	EE19	2-42
	EE22	2-51
	EE25	2-59
	EE34	2-78
	EM42	2-87

# APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

## Emissions and Monitoring (EM)

Following is a list of all projects related to each of four subcategories of the Emissions and Monitoring (EM) research category.

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Emissions - inventories, reduction scenarios	EE3	3-5
	EM6	3-11
	EM10	3-19
	EM11	3-21
	EM18	3-36
	EM19	3-39
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Ambient air monitoring - measurements, techniques, instruments	AP7	1-13
	AP10	1-23
	AP15	1-33
	EE13	2-25
	EE17	2-35
	EE18	2-39
	EM5	3-9
	EM6	3-11
	EM7	3-13
	EM8	3-15
	EM9	3-17
	EM16	3-32
	EM19	3-39
	EM21	3-43
	EM23	3-49
	EM25	3-53
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APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

Emissions and Monitoring (EM) (continued)

<u>Subcategory</u>	<u>Project</u>	<u>Page</u>
Wet deposition monitoring - measurements, techniques, instruments, data analysis	AP7	1-13
	AP8	1-17
	AP10	1-23
	AP15	1-36
	EE13	2-25
	EE15	2-29
	EE17	2-35
	EE18	2-39
	EE22	2-51
	EE25	2-59
	EE32	2-72
	EE34	2-78
	EE35	2-80
	EE38	2-86
	EM1	3-1
	EM2	3-3
	EM3	3-5
	EM4	3-7
	EM5	3-9
	EM12	3-23
	EM13	3-26
	EM14	3-28
	EM15	3-30
	EM16	3-32
	EM17	3-34
	EM20	3-41
	EM21	3-43
	EM23	3-49
	EM25	3-53
	EM26	3-55
	EM29	3-61
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	EM31	3-65
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	EM36	3-75
	EM37	3-77
	EM38	3-79
	EM39	3-81
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APPENDIX A. CROSS REFERENCED SUBJECT INDEX (continued)

Emissions and Monitoring (EM) (concluded)

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**FUNDING ORGANIZATION INDEX**

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DuPont Petroleum Chemicals  
Exxon Research & Engineering Company  
Exxon U.S.A.  
Getty Oil Company  
Gulf Oil Corporation  
Marathon Oil Company  
Mobil Research & Development Corporation  
Murphy Oil Corporation  
Occidental Petroleum Corporation  
Pennzoil Company  
Phillips Petroleum Company  
Shell Oil Company  
Standard Oil Company (Indiana)  
Standard Oil Company (Ohio)  
Sun Company Inc.  
Texaco Inc.  
Union Oil Company of California  
Western Oil & Gas Association

#### Gas Industry

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Boston Edison Company  
Cincinatti Gas & Electric  
Colorado-Ute Electric Association, Inc.  
Detroit Edison  
Duke Power Company  
Duquesne Light Company  
Edison Electric Institute  
Electric Power Research Institute  
Empire State Electric Energy Research Company  
Florida Electric Power Coordinating Group  
Iowa-Illinois Gas & Electric  
Long Island Lighting Company  
Madison Gas & Electric  
Minnesota Power & Light  
Minnesota/Wisconsin Power Suppliers  
Mississippi Power Company  
Niagara Mohawk  
Northern State Power Corporation  
Ohio Edison Company  
Pacific Gas & Electric  
Pennsylvania Electric Company  
Pennsylvania Power & Light  
Public Service Co. of Colorado  
Public Service Co. of New Mexico  
San Diego Gas & Electric  
Southern California Edison  
Southern Company Services  
Southwestern Public Service Company  
Tennessee Valley Authority  
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Union Electric Company  
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American Mining Congress  
American Paper Institute  
American Rivers Conservation Council  
ARMCO  
ASARCO  
Bass Anglers Sportsman Society  
Bass Research Foundation  
Bethlehem Steel  
Bio-Energy Council  
Bituminous Coal Research  
Boise-Cascade Corporation  
Center for Law & Social Policy  
Charles T. Main, Inc.  
Chemical Manufacturers Assn.  
Clean Water Action Project  
Common Cause  
Congressional Research Service  
Consolidated Papers Incorporated  
Consolidation Coal Company  
Coordinating Research Council, Inc.  
Cornell University  
Council of Industrial Boiler Operators  
Engine Manufacturer's Association  
Environmental Action  
Environmental Defense Fund  
Environmental Law Institute  
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J & L Steel  
Kennecott Copper  
Los Angeles Department of Water and Power  
Magma Copper Company  
Meade Paper Company  
Mining & Reclamation Council of America  
Motor Vehicle Manufacturer's Association  
National Association of Corrosion Engineers  
National Audobon Society  
National Atmospheric Deposition Program  
National Clean Air Coalition  
National Coal Association  
National Council of the Paper Industry  
for Air and Stream Improvement  
National Crushed Stone Institute  
National Fisheries Institute  
National Forest Products Association  
National Independent Coal Operators Association  
National Lime Association  
National Limestone Institute  
National Paint and Coatings Association  
National Resources Defense Council  
National Rural Electrification Cooperative  
Association  
National Wildlife Federation  
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Ohio Agricultural Research & Development  
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TRC, Environmental Consultants, Inc.  
Trout Unlimited  
Union Pacific Corporation  
University of Colorado  
University of Pittsburgh  
University of Pennsylvania  
University of Rhode Island  
University of Toledo  
U.S. Steel  
Western Forestry and Conservation Association  
Wisconsin Paper Council